DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

AUGUST 1959

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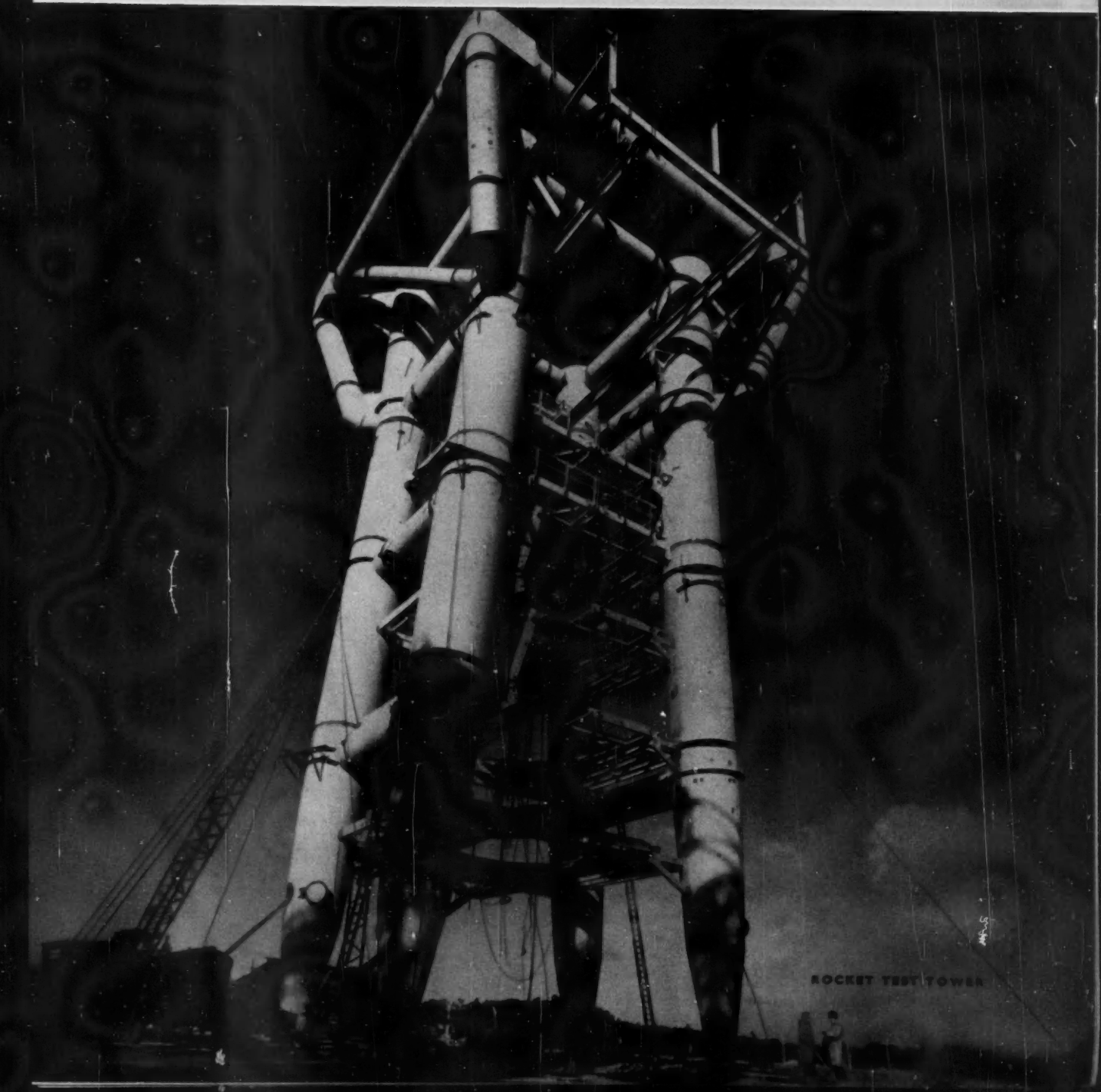

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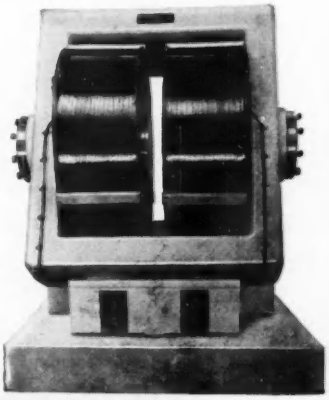

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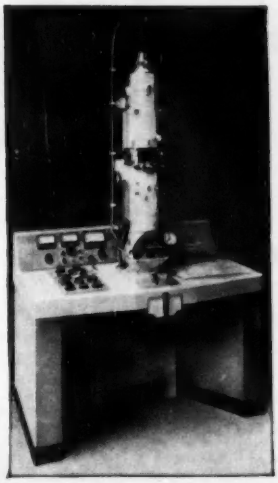

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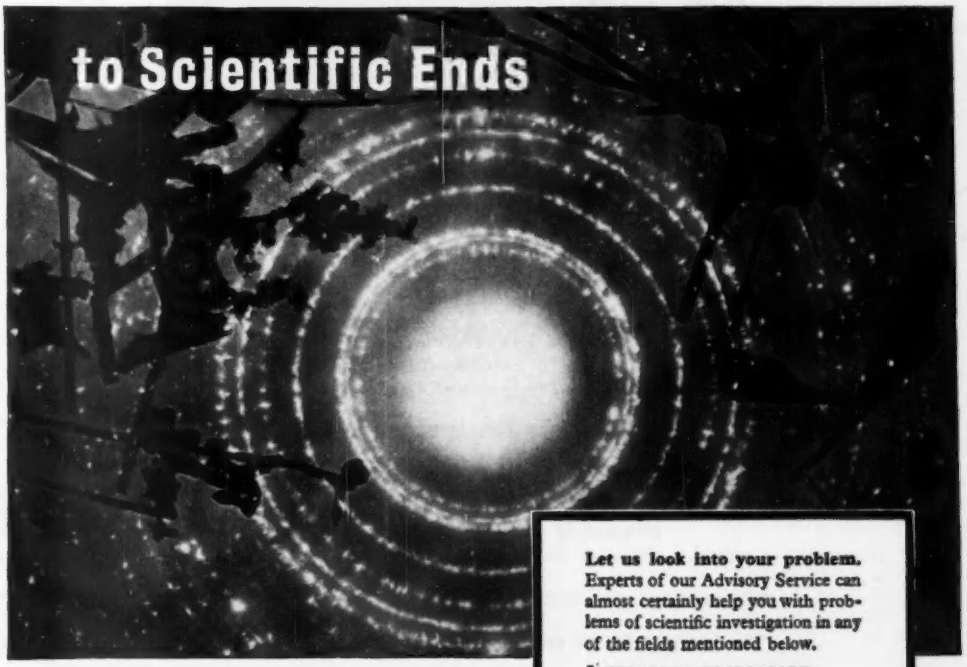

Information on crystal structure, particle size and shape. Illustration shows diffraction pattern of zinc oxide smoke superimposed on its electron micrograph.

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DISCOVERY

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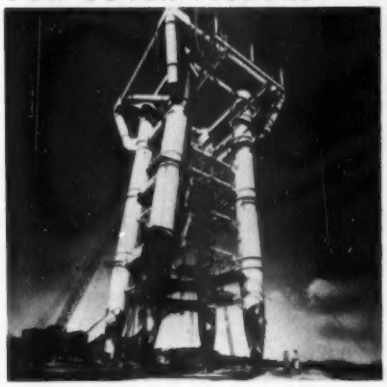
OUR COVER PICTURE



This tower is to be used for development work associated with launching problems of *Blue Streak*, the British Long Range Ballistic Missile for which de Havilland Propellers Limited is the the overall design authority, heading a team which also includes the de Havilland Aircraft Company, responsible for the structure of the missile, Rolls-Royce who manufacture the engines, and the Sperry Gyroscope Company Limited who are developing the guidance system. *Blue Streak* is a surface-to-surface missile designed to carry a nuclear warhead over a range of several thousand miles with extreme accuracy: development work is advanced and testing has begun at a number of centres in this country, notably at Hatfield and will start shortly at Spadeadam Waste in Cumberland, where captive missile firing trials will be carried out. Test launchings of the missile will be made on the extended rocket range at Woomera in Australia. The tower is 100 ft. high and of tubular steel construction.

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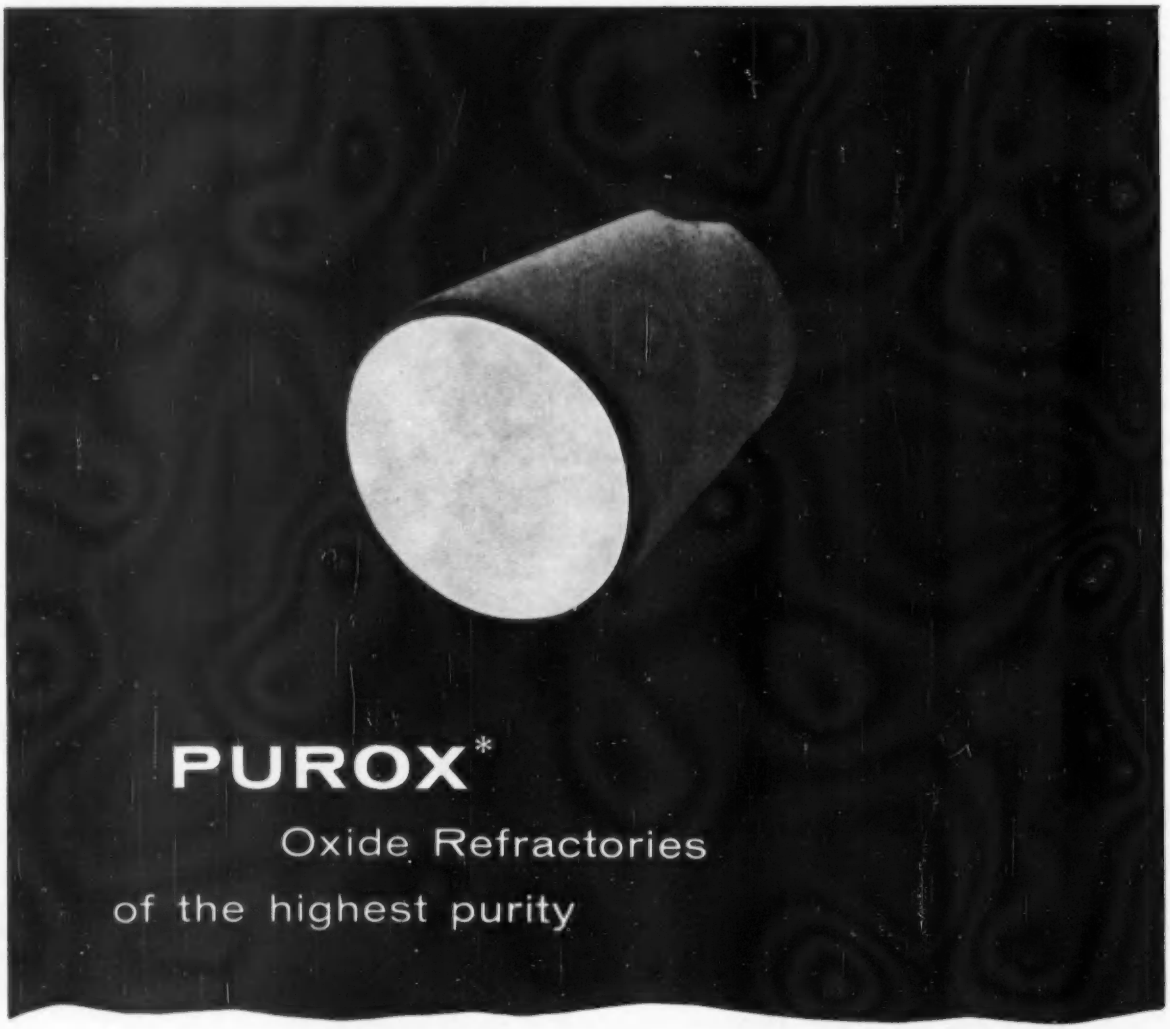

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THE PROGRESS OF SCIENCE

SPOTLIGHT ON DSIR

Two themes have always been stressed in these columns: the need to take a long view of social and economic problems so that science can make an effective contribution, and the importance of the scientific method in the actual deployment of science. We welcome, therefore, the latest report* of the Council of the DSIR which both outlines the Department's expenditure under its second five-year plan, rising from £36 million to £61 million every five years, and generally examines its strategy.

The Department's long experience bears witness to the main problems confronting the Government both as a practitioner and a patron of research. Thus, in October 1955 a committee of inquiry into the DSIR included in its findings the fact that the existing central direction of the scientific effort at the Department's research stations was "inadequate", and that the research programmes had become "too diffuse or too uneven in quality". It is a healthy sign that the new Research Council is now systematically appraising the Department's work and has put in hand important studies on the specifically economic implications of the Department's scientific programme. If these latter are not as extensive as we would like, it is probably due to a traditional conservatism at the Treasury. Moreover, it should not be thought that the DSIR is a lavish spender: its present annual budget of £9 million rising to £14 million by 1964, should be seen against a national product for civil industry, whose needs it ultimately serves, of around £10,000 million. Sixty per cent of the DSIR budget goes to the fourteen research stations. For these, the Council lays down three main areas of research: helping central and local authorities; improving the efficiency of the economy as a whole; and providing industry with basic information for carrying out the applied research necessary to solve particular problems. While confirming that there is a large and growing field for the research stations within this framework, the Council stresses the need for careful selection of the most important projects and "a concentration of the available resources". Vital streamlining in the work of the National Physical Laboratory, the National Chemical Laboratory and the Mechanical Engineering Research Laboratory is being effected: the more general (*sic*) Warren Spring Laboratory, which has important tasks in fuel research, has been established: while, more controversially, perhaps, the siting of some microbiological and forest-products research is being moved from the Department to the universities and industry respectively. Though it is well known that the Advisory Council on Scientific Policy recommended that the annual supply of science and technology graduates between 1955 and the late 1960's should be doubled, the fact that the Department has recently become the main agency supporting post-graduate students in these fields is not so well known. It now proposes to raise the number of new DSIR studentships from nearly 1000 to 1900 in 1963–4. Grants for special research will increase even more rapidly, three to four times in money terms, and in some areas yet further; it is also intended to give financial help for longer terms to outstanding university investigators embarking on promising lines of research for which the universities cannot make adequate provision. Yet for all these ambitious plans to help research at the universities, this outlay, at the end of five years, will account for a mere 10% of DSIR expenditure.

It would be wrong to be too complacent about the scientific manpower outlook: moreover, the report records one dangerous sign, that "through lack of good candidates" the number of new advanced course studentships awarded "fell rather far short of the maximum for which we had provided finance". Even more disturbing for the future could be the fact that only twenty-three, 6%, of the research students of the last year's output took up posts in schools and technical colleges. But perhaps the saddest commentary concerns the human sciences. The Research Council's decision to allocate £53,000 in the year 1957–8 for new awards and contracts in this field is, in relation to its estimable aims, scarcely realistic.

Finally, the Council's review of the grant-aided Research Associations provides a convincing vindication of co-operatively financed research, with a balance between the desirability of a government contribution to ensure basic research and the need to encourage a growing contribution from industry. Certainly the Council's efforts to get industry to stand more on its own feet where research is concerned will have a sympathetic reception, since it goes to the heart of our industrial problem. No doubt there will be a welcome for their concern for the small firm, and their declared willingness "to consider proposals for the support of industrial research and development . . . which is likely to lead to results of value to the nation as a whole". This is an important new step, and protestations that it will overlap with the National Research Development Corporation, whose policy must be financially more prudent, is misplaced. What is surprising is the Department's implied willingness to support large organisations "whatever the scale". Given the resources of the latter this carries a tacit admission of British industry's extreme caution in financing scientific research. How this outlook can be modified and what, if any, fiscal incentives would help is a matter of great importance.

DSIR is the most important agency for Britain's civil research. Though there are many major queries, not least regarding its role and that of government scientific machinery generally, its work merits the highest praise.

* Department of Scientific and Industrial Research: "Report of the Research Council for the Year 1958." London, Her Majesty's Stationery Office. 3*s*. 6*d*. Cmnd 739.

Owing to the Printing dispute this issue of DISCOVERY has been delayed, but there has been no break in the sequence of continuous publication.

LEVITATION FOR TRANSPORT

A recent demonstration of the Hovercraft, made by Saunders-Roe Ltd of Cowes, Isle of Wight, based on a contract placed by Hovercraft Development Ltd, showed development of a man-carrying experimental saucer-shaped craft. This invention was the result of experiments carried out by Mr C. S. Cockerell as a private venture in 1953, until the National Research Development Corporation sponsored the discovery of the new vehicle, which proved to be suitable for use over water and land.

Designated the SRN 1, the prototype is about thirty feet in length and twenty-four feet wide. It is powered by an Alvis Leonides 450-h.p. engine, which drives a ducted fan to supply the airstream for lift and propulsion. Being neither an aircraft nor a ship, the Hovercraft operates clear of the water at about three to seven feet above the surface. The lift principle is generation of a cushion of air under the bottom surface of the vehicle. The cushion is contained within a curtain of air flowing downwards from the craft.

The air is ejected through nozzles which face towards the centre of the craft. The vertical component of the direct thrust forms a negligible part of the total air lift. The air cushion is carried along with the craft. Hand-carved wooden fan blades are used to provide the lifting force and bleed-off air for propulsion. The pre-rotational vanes and the blanking assembly are dowelled. The propulsion ducts are double-skinned and mounted on plywood rings.

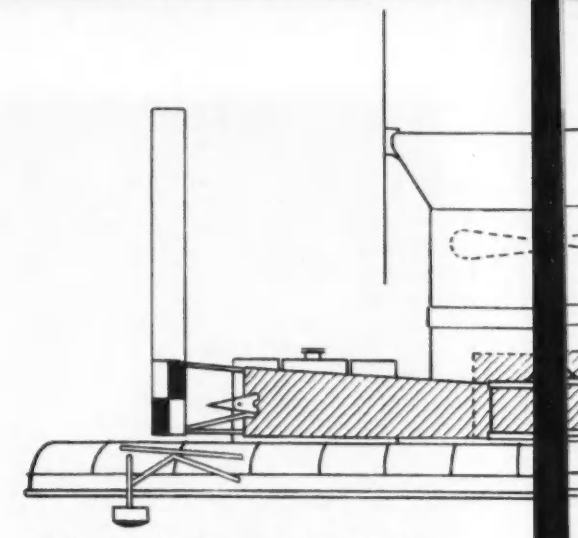
It is claimed that new and exciting possibilities are offered for travel and load transport. For example, the craft may be loaded on land, thus making harbour and expensive port facilities unnecessary. The Hovercraft is likely to find its first practical uses as a fast ferry over medium distances, such as a ten- to twenty-minute journey between England and the Continent. It will probably take some years to develop an ocean-going Hovercraft, but engineers are confident that this will fill a gap between large surface ships and transport aircraft.

The development potential of the Hovercraft is also envisaged for use on land. For example, a land vehicle may be built to operate at speeds up to 100 miles per hour. Its length would be twenty-seven feet with a laden weight of 4¼ tons. It could carry sixteen passengers or 1½ tons of freight. This land craft would not necessarily require conventional roads or bridges, and might travel along a trackway free from obstacles but otherwise left rough. The possibilities for opening up remote areas in large countries, such as Canada, Australia, and Africa, are obvious.

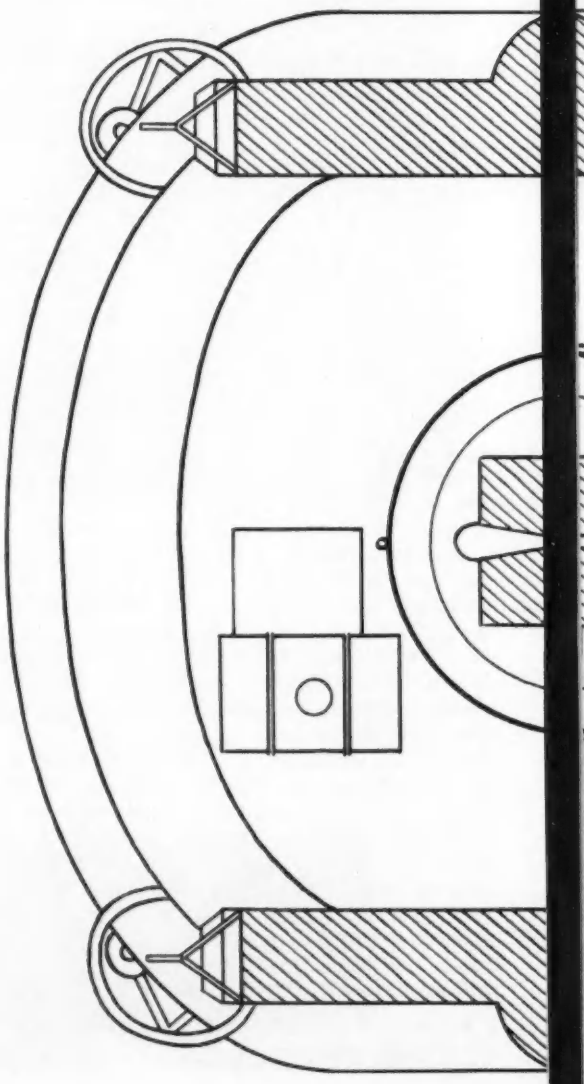
In the following, an American discovery will be described which is based on somewhat similar principles, but on a different design.

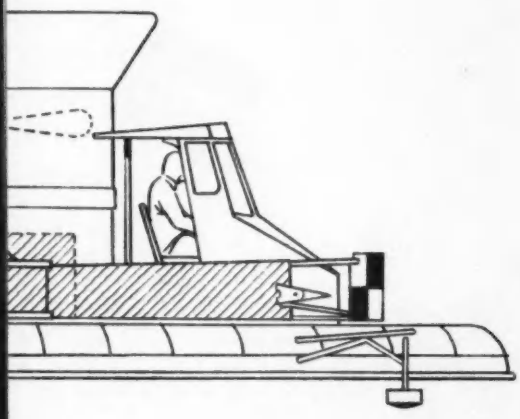
A new principle for vehicles has been demonstrated at Ford Motor Co.'s Research and Engineering Centre at Dearborn, U.S.A.—the principle of levitation for high-speed ground transportation upon which the Hovercraft is based. Thus the spiritualist's phenomenon of keeping a solid body in the air, outside the orbit of gravitation, seems to have reached a practical everyday appearance. Speeds visualised are from 200 to 500 miles an hour, which sounds fantastic for Great Britain anyhow, unless long, straight, motor-roads can be made available for fast trips up to about 1000 miles.

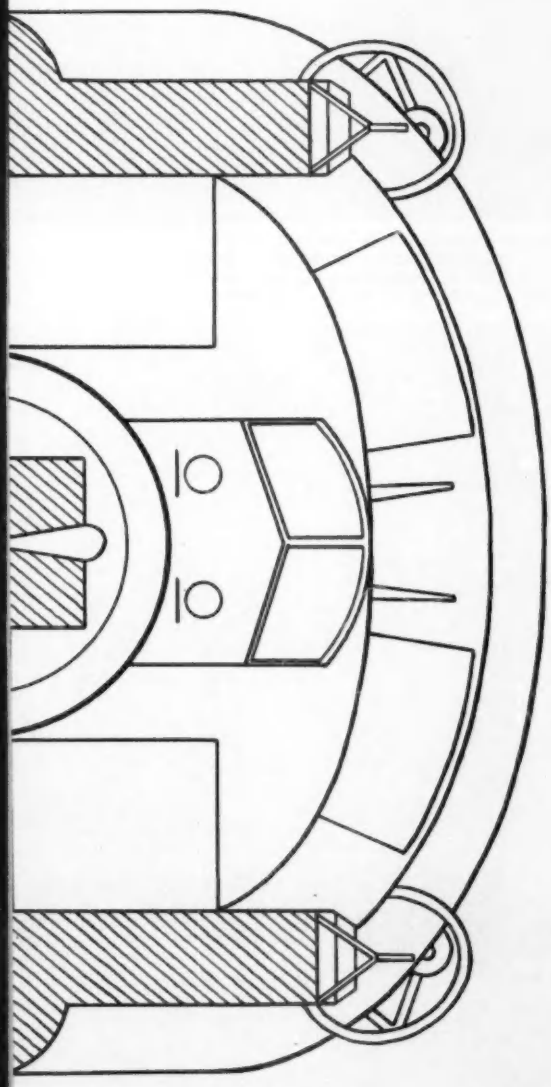
The development of Ford's Glideair vehicles was stimu-



Diagrammatic drawings of the Saunders-Roe SRN 1 Hovercraft (*above*) side view and (*below*) from above.







lated by the fact that land transportation has lagged far behind air porterage in spite of the advent of faster automobiles and improvements in highways. This is because of road friction from wheels, the human control factor, and the cost of superspeed highways.

The successor to the motor-car of today is a wheel-less vehicle that rides on a thin film of air a fraction of an inch above the road. Instead of wheels the Glideair employs so-called "levapads", a word coined by Mr Andrew A. Kucher, Vice-President of Ford's. Tiny jets of air go through holes in the levapads and support the vehicle. Air is used as a lubricant, and since the Glideair is propelled by reaction, a gas-turbine engine is well capable of supplying the power to both levitate and propel it. The vehicle could also be designed to ride on rails, or a monorail overhead system.

Calculations show that about 50 h.p. will be required to levitate one ton of vehicle weight. Once free from the road-bed it requires only about 40 additional h.p. to move it 100 miles an hour. Thus a 2-ton truck would require about 180 h.p. for transport of goods at 100 miles an hour. To travel 400 miles an hour would take about 800 h.p. per ton weight. A low-speed turbojet engine developing only 1000 lb. thrust would be of small size (about 4 to 5 ft. long and 18 in. in diameter) and very economical for a 2-ton truck.

Engine horse-power and thrust can be calculated at 375 miles an hour by the simple relation that 1 h.p. equals 1 lb. thrust. For example, one vehicle weighs 1 ton, and another 50 tons. If both offer the same frontal area to wind resistance it would require only slightly more power to drive the far heavier one at the same speed, provided levitation would be applied.

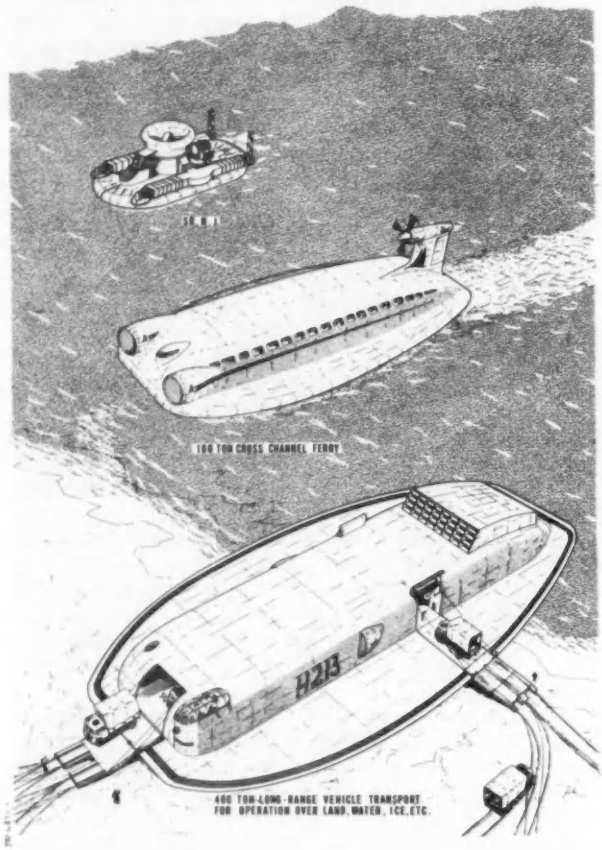
A comparison between a four-engined plane (DC6B) with a take-off weight of 100,000 lb. and a Glideair vehicle of the same weight is as follows. The aircraft has four engines each of 2400 h.p., or 9600 h.p. in total. The Glideair would require only 2500 h.p. to levitate (50 h.p./ton) and about another 1800 h.p. to drive it 400 miles an hour. This is less than one-half the power required by the aircraft. Additional payload saved from omission of weight of wings or control tails (60% of weight of the aeroplane) is another beneficial factor. A journey of 300 miles in the Glideair would, of course, take longer than by a fast aeroplane, but would require less than one hour. It seems reasonable that under U.S.A. conditions a minimum trip of 100 miles may be necessary to justify the speeds under consideration. Public vehicles for passenger and goods transport would probably be in the forefront of consideration.

It is claimed by the designers that ground travel in Glideair vehicles will be safer than air travel. Being on the road—or rail surface, most failures will allow the vehicle to slide to a stop. The air supply will function sufficiently long after power failure, permitting the vehicle to stop with little if any damage.

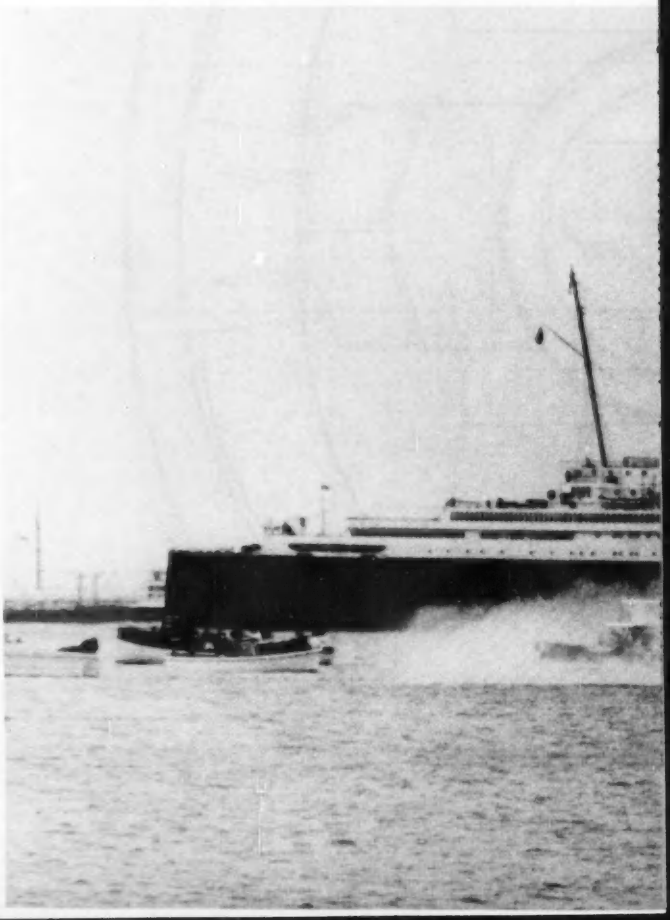
The big question mark in the whole scheme, however, are roads. Although it is expected that a Glideair track can be laid more cheaply than a lane of concrete, traffic at high speeds as visualised would require very special motorways. The position in the U.S.A. and on the Continent is very different from conditions in the British Isles. We are still in the prongs of very, very small beginnings where 14 to

Hovercraft

DEVELOPMENT POTENTIAL

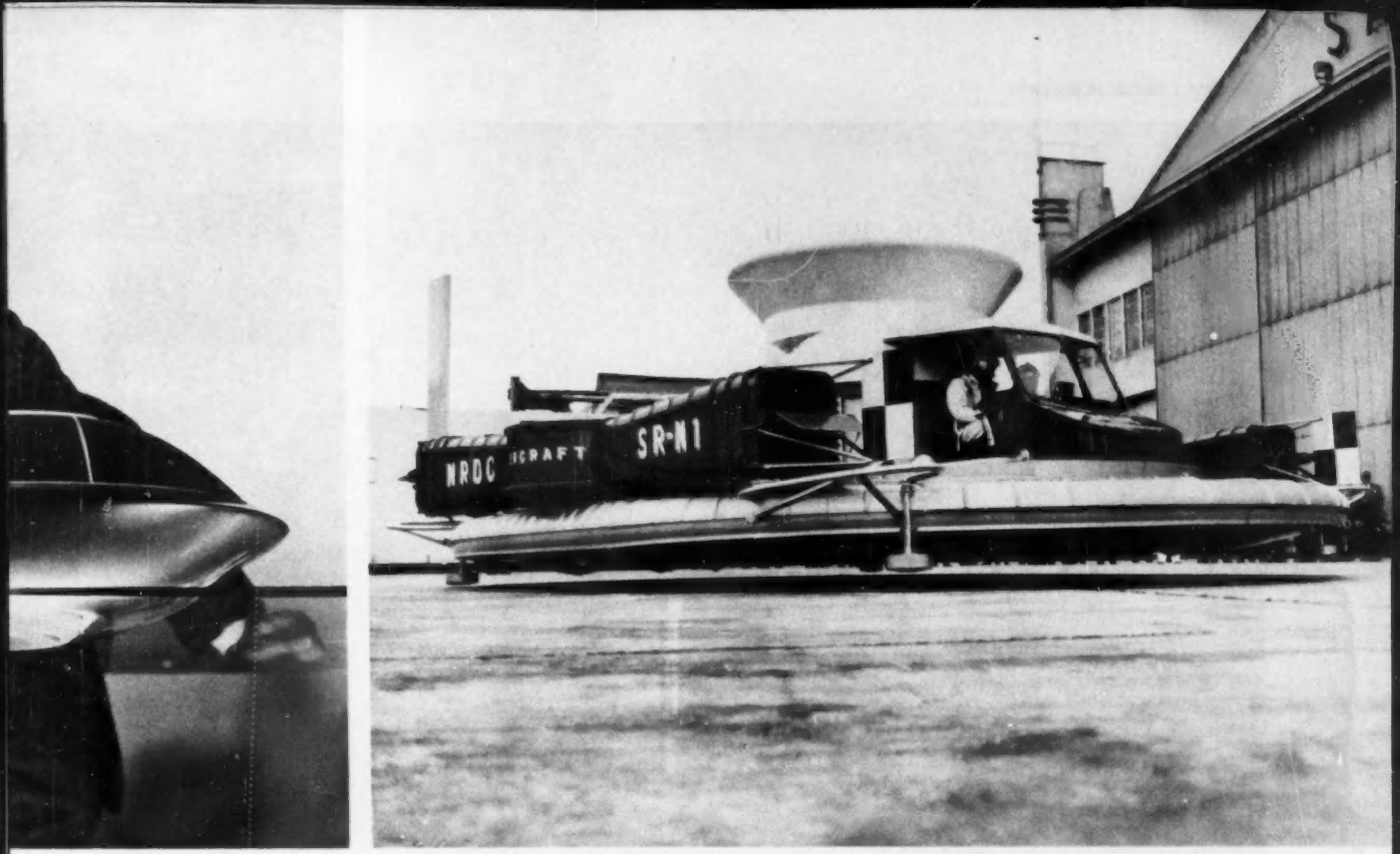


(*Above*) Underside view (through glass) of Levapads on the Ford Motor Company's model vehicle.
(Photograph by courtesy of Ford Motor Company, Dearborn, Michigan, U.S.A.)



20 miles of motor highways are hailed as a grandiose achievement, where ten times these lengths would be much more to the point. There is no doubt that the road surface would have to be very smooth and uniform for Glideair transport. Holes in the road could not be tolerated, and swinging out over the kerb in case of emergency might damage the levapads. It is certainly too early to tell what the future will hold for the Glideair in its homeland. The Ford engineers do not anticipate that it is going to replace conventional road vehicles, or transport aeroplanes. They expect, however, that it will add a mode of its own to transport.

We in Great Britain will certainly watch with much interest the coming technical developments of the Glideair and the Hovercraft. Whether our motor-road developments, proceeding at a snail's pace at the present time, will allow the use of very high speeds, as inherent to economy of hover transportation remains to be seen. Our authorities will have to build motorways faster, to be ready for the age of levitation.



(*Below*) The old and the new. The SRN 1 Hovercraft is dwarfed by the liner *Queen Mary* as it demonstrates its hovering ability over the sea at Cowes, Isle of Wight.

(*Above*) The SRN 1 Hovercraft 15 in. above the ground.

PETROLEUM CHEMICALS

A quarter of a century ago the petroleum chemical industry was in its infancy. Today petroleum is the source of a vast range of valuable chemicals produced at a rate of well over a million tons a year. These chemicals are the building blocks for such products as detergents, solvents, synthetic resins and plastics, synthetic rubbers and textile fibres. Industrial and agricultural chemicals are also among the hundreds of other petroleum-derived chemicals in use.

In many cases petroleum-derived chemicals are used alongside identical chemicals obtained from other raw materials like coal, molasses, or grain. But the relative importance of petroleum as a raw material is constantly increasing, so other sources can be released for use as food and fuel.

The petroleum chemical industry has its roots in the U.S.A. In the years following the First World War the mass production of motor vehicles in the U.S.A. led to a great increase in demand for petrol. To meet this demand the petroleum industry developed various new refining processes, but besides the petrol the processes also produced large quantities of gaseous materials. These contain a series of gases which, because of their reactive nature, are good raw materials for the manufacture of chemicals.

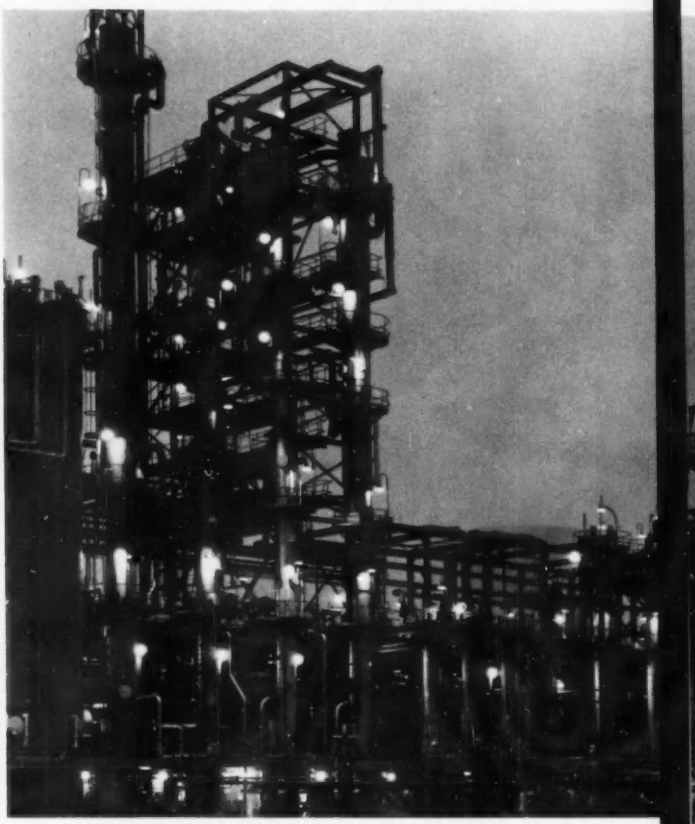
The main development in the 1930's was the production of chemical solvents for use in paints and lacquers for the rapidly growing American automobile industry. At the same time the possibility arose of making chemicals based on the cheap and abundant supplies of natural gas available from the many oilfields in the U.S.A. This led to the large-scale manufacture of carbon black and ammonia. The carbon black was needed for the rubber tyre industry. The ammonia, besides its industrial uses, was to be used for fertilisers.

Demand for chemicals during the Second World War resulted in a great expansion of the petroleum-based chemical industry. Apart from the additional demand for military purposes, it was necessary to replace a number of essential materials whose supplies were either reduced or cut off. During this period synthetic rubbers, synthetic alcohol, and synthetic detergents made largely from petroleum, really began to take the place of their counterparts made from other raw materials. Since the war the production of these synthetic materials has continued to grow, and the range of chemicals produced from petroleum sources has at the same time greatly increased.

Petroleum chemicals can be divided into two types—organic and inorganic. The organic chemicals are basically composed of carbon and hydrogen but often contain certain other elements, notably oxygen, chlorine, sulphur, and nitrogen.

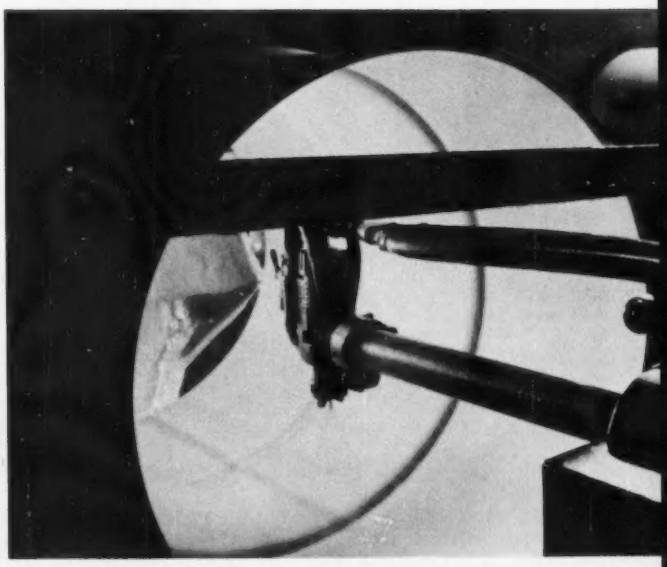
Examples of inorganic chemicals which can be derived from petroleum are ammonia, sulphur, and hydrogen peroxide. The unit value of inorganic chemicals is, however, much lower than that of the organic chemicals. In 1956 the output of these inorganic chemicals in the U.S.A. represented about half as much in tonnage, but only about one-ninth as much in value, as the petroleum-based organic chemicals.

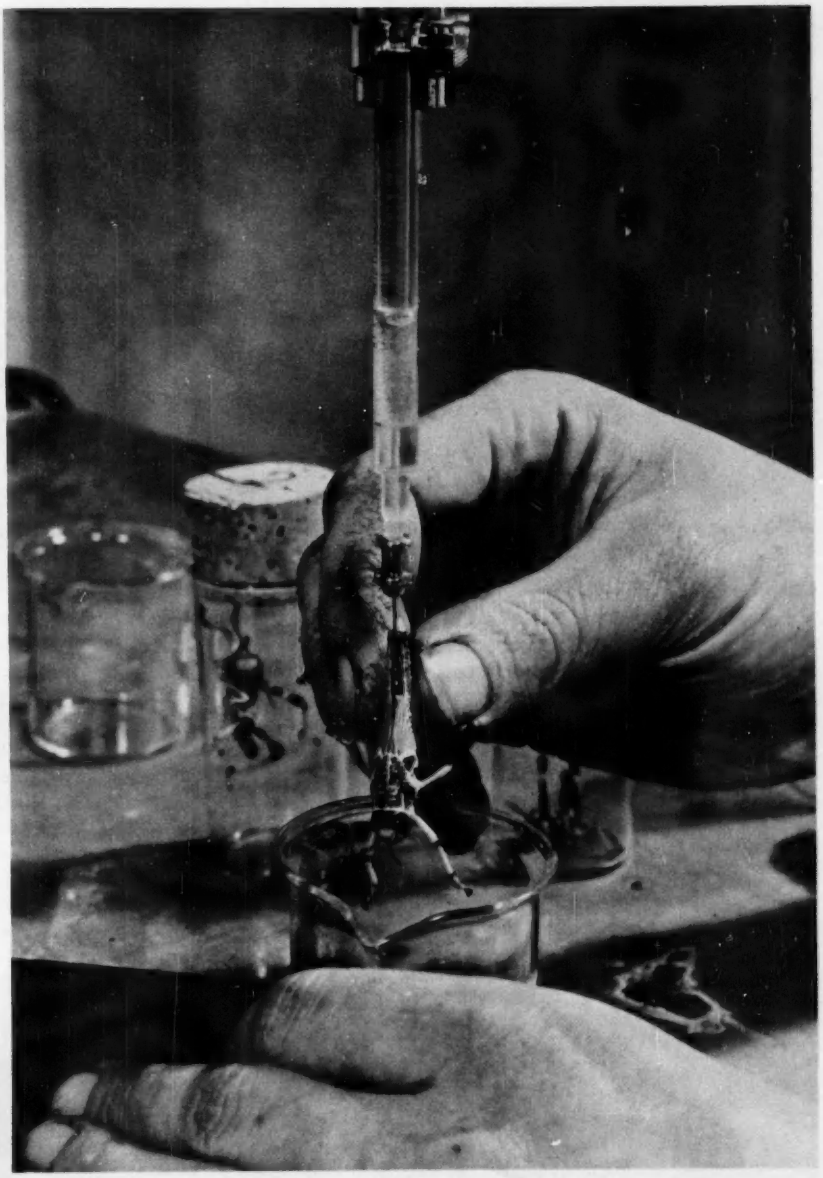
Since 1940 the production of organic chemicals from petroleum in the U.S.A. has grown at an average rate of



(*Above*) The steel columns and framework of this complex chemical unit at Stanlow, Cheshire, occupy space equivalent to a large office block. Manufacturing is maintained ceaselessly throughout the day and night, and the plant is brightly lit after dark to enable workers to continue their supervision duties. This plant is the gas fractionation equipment of the ethane-ethylene unit.

(*Photographs by courtesy of Shell*)





(*Right*) Oil chemicals have produced insecticides which help to control insect pests in many parts of the world. Before being used in the field, the chemicals are tested under simulated conditions in laboratories. In this picture the quantity needed to kill a locust is being ascertained by injecting a tiny volume of dieldrin insecticide into a live locust in a laboratory at Woodstock, Kent.

(*Left*) The hard-wearing properties of resins obtained from petroleum sources have many industrial applications. In this picture, Epikote, a resin, is being sprayed as a protective coating against corrosion inside an oil-drum.

between 20% and 25% a year, compared with a rate of increase of between 5% and 10% a year for the chemical industry as a whole. The rapid expansion of the chemical industry in the U.S.A. during the post-war years has been to a great extent due to ample supplies of raw materials from petroleum.

In Western Europe the growth of the petroleum chemical industry has taken place almost entirely since the Second World War, and most of it since 1950. The first plant to make chemicals from a petroleum feed-stock came into operation at Shell's Stanlow Refinery in the U.K. in 1942. It produced synthetic detergents. An important difference between the U.S.A. and Western European petroleum chemical industries is that most of the European developments have relied upon the special processing of liquid

The cleaning properties of detergents, manufactured from oil chemicals, have found many uses for domestic and industrial purposes. In this picture, raw wool is being immersed in detergent solution to remove natural oils and greases during the scouring process.

petroleum feed-stocks to produce the required gases. This difference has developed partly because insufficient supplies of the gases were available from the oil refineries, and partly because much of the development in the petroleum chemical industry has been by chemical companies who preferred to keep the production of these gases under their own control. Recently, however, refinery gases have been used a great deal more, and natural gas is being used in several countries in Europe.

Capital investment in the petroleum chemical industry in Western Europe exceeded £160 million by the end of 1956. The United Kingdom's share was over £70 million, and it is expected that these figures will be doubled by 1960.

The U.S.A. and Western Europe together account for over 95% of current petroleum chemical output in the free world. Most of the remaining 5% is produced in Canada. Japan started production in 1957 and has announced plans for the development of an extensive petroleum chemical industry in the next few years.

Looking to the future, the industry has the advantage of being able to supply very large quantities of raw materials at relatively stable prices. In the production of organic chemicals this is especially important, since alternative raw materials—which in the past have fluctuated both in quantity and price to the obvious disadvantage of the chemical manufacturer—cannot be produced in sufficient quantities to meet the increasing demand for organic chemicals.

The industries using petroleum chemicals are expanding rapidly, and there is every chance that the present world output may be trebled in ten years.

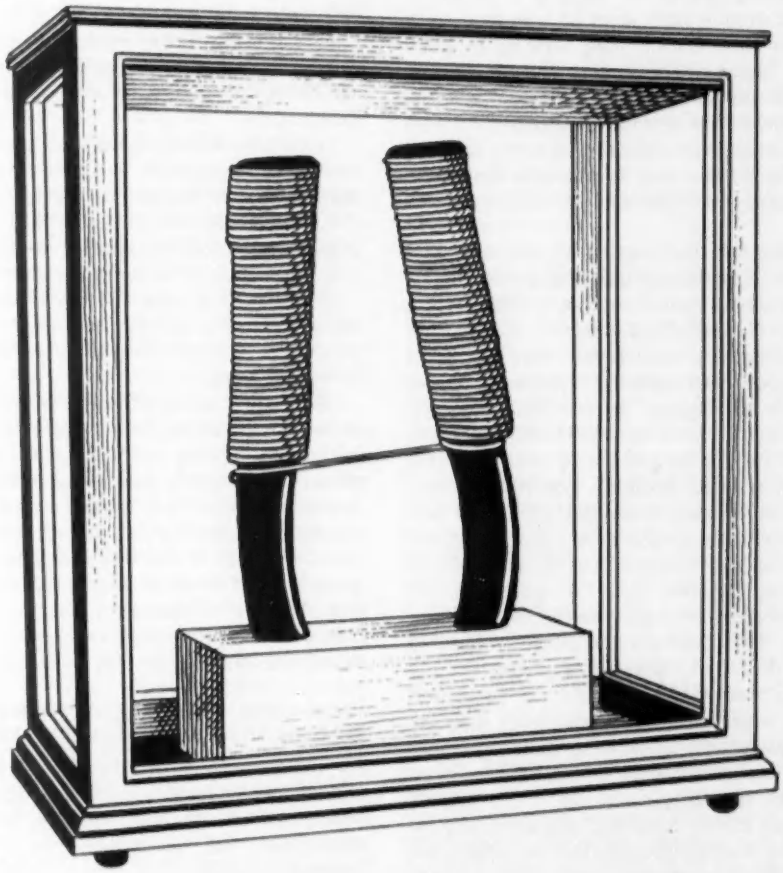
Automation handles the flow of products through the refinery processing plant, while skilled staff keep a check on the rate of progress and the high temperatures and pressures inside each unit. These control-room operators are observing reactions which are taking place inside a gas separation plant at Stanlow, Cheshire.

FARADAY'S WOOLWICH MAGNET OF 1830

It is not well known that Faraday's culminating experiments on the continuous production of electricity by magnetic induction, probably the most important of his investigations, were carried out during 1831, at the house of Mr Christie, a member of the mathematical staff of the Royal Military Academy at Woolwich.

Faraday had been since 1829 a part-time lecturer and later a Professor at the Academy, where he taught the rudiments of chemistry and natural philosophy to the very young cadets. Faraday held this appointment for nearly twenty-nine years, although resident Fullerian Professor of Chemistry at the Royal Institution. The results of his experiments were given to a Royal Society meeting on November 24, 1831, and were published in the *Philosophical Transactions* of 1832 under the title "The First Series of Experimental Researches in Electricity". At that time the Academy had on its staff, or there were resident locally, many personalities who were well known for their scientific pursuits. Such names as Barlow, Beaufort, Cruickshank, Sturgeon, and Marsh can be mentioned.

In 1823, William Sturgeon, who had been a gunner in the Artillery at Woolwich, a Professor at the East India Company's Military Academy at Addiscombe, and finally Superintendent of the Victoria Gallery at Manchester, was constructing ingenious pieces of apparatus for demonstrating electrical and magnetic phenomena. For this he was awarded the Royal Society of Arts' silver medal and 30 guineas in 1825. Included in Sturgeon's apparatus was the first known electro-magnet, a piece of iron shaped like a small horseshoe, coated with varnish for insulation, and having a single winding of bare copper wire. He also constructed a vibrating plate apparatus, with which he measured the strength of his magnetic fields, taking the rate of damping of a sheet of copper swinging between the pole pieces of his magnets.



A similar apparatus was used by Faraday during his experiments of 1831. The Royal Institution possesses a large horeshoe magnet used by Faraday in his researches of 1849. The Royal Military Academy Museum, now incorporated with the Military College, Sandhurst, in Surrey, possess a magnet (a drawing of which is shown) that is improved upon by the American, Henry, between 1825 and 1829 with his many-layered windings. The Woolwich magnet, although much larger than Sturgeon's, has short multi-turn coils at the ends of each limb. There is no definite reference in Faraday's notes or diary to the construction or use of this particular magnet and it is therefore presumed that this was undertaken for the instruction of the cadets between 1829 and 1830. This could have been the showpiece of the Faraday Centenary Exhibition of 1931 and is still presumably unknown to many.

CIBA COLLOQUIUM ON AGEING

It was recently said that most men in their sixties are now considered, by themselves at least, to be merely middle-aged. This question of increased expectation of life, in animals as well as in man, was examined in some detail at the fifth Ciba Foundation Colloquium on Ageing,* at which Prof. J. F. Danielli (London) took the chair.

Dr B. Benjamin (London), who dealt with the actuarial aspects of human lifespans, pointed out that in western countries many people reach somewhat greater ages than they did a hundred years ago, and he suggested that attention might now be directed to early signs of degeneration in healthy lives. Work on these lines is being done by Dr B. N. Berg and Prof. H. S. Simms (New York), whose thesis was that longevity depends on the age of onset of lesions of the major diseases of a particular species; in this respect man is similar to the rat, except that the age of onset is much later in man. Dr Berg showed that in male rats the age of onset of several diseases studied can be deferred by a restricted diet.

On the other hand, an improved diet with adequate proteins and vitamins lengthened the lifespan of female houseflies in Prof. M. Rockstein's laboratory (New York). Mr J. Maynard Smith (London) has observed, also in flies, that different processes are responsible for ageing at different temperatures, in both males and females, and that egg-laying accelerates the ageing of females. Similarly, Dr Anna Maurizio (Berne) showed that restricted brood-rearing was essential for the longer life of over-wintering as opposed to summer bees. Prof. F. Bourlière (Paris), studying populations in the wild, found that small and fast-breeding birds and mammals usually have shorter lifespans than larger, slow-breeding animals. Dr S. D. Gerking (Bloomington, Indiana) reported that for egg-laying fish reproduction is probably an increasing strain as they grow larger and older, so that it is either a direct or indirect cause of death. Dr R. J. H. Beverton (Lowestoft) and Dr S. J. Holt (Rome) observed that female fish, in natural populations, grow to larger sizes but more slowly than the males, and live longer. Where there is no clear difference between the growth rates of the sexes there is also no clear difference between the mortality rates. Dr R. F. Nigrelli (New York), discussing fish in captivity, said that lifespans could be increased by careful management of conditions, and that apart from environmental stress, the primary causes of death in captivity are diseases similar to those found in mammals.

Atherosclerosis has not yet been observed in fish, but Prof. S. Scheidegger (Basle) described the disease as seen in birds. Discussion established that a carnivorous diet was unlikely to be the main cause, since few birds are purely carnivorous. Recent experiments show that exercise may retard or prevent the disease.

Diseases, infertility, and economic factors were shown by Dr W. Hartwig (Halle, Germany) to be the main reasons why most cattle are slaughtered before they reach their most productive years. Dr Hartwig did not agree that increased productivity would decrease the lifespan of cattle.

Dr A. Comfort (London), reporting General Stud Book data on horses, said that there was no good evidence of a consistent effect of parental age on longevity in mares, but that the progeny of two long-lived parents had a greater expectation of life than the progeny of two short-lived parents. (In Prof. Rockstein's flies, the longevity of female offspring of old parents was more adversely affected than that of males, the male offspring of old females even tending to live longer than usual.) In man, Prof. Eeva Jalavisto (Helsinki) reported that according to figures from family records, maternal age has an adverse effect on the children only during the first two years of life, and then only if the mother is thirty-five or over. Favourable economic circumstances tend to eliminate maternal age effects, and paternal age did not seem to have any influence on the mortality of the children.

Mr G. A. Sacher (Lemont, Illinois) related lifespan to brain weight and body weight in mammals and his paper aroused much discussion. His statistical analyses imply that an increase in the relative size of the nervous system is associated with an increase in the attainable length of life, when the rate of energy expenditure is constant.

The females of most of the species mentioned live longer than the males, and Mr Maynard Smith showed that, in flies at least, this is caused by genes with different effects in the two sexes.

Many other points of interest, including radiation effects, and further discussions on genetic effects, were raised during the meeting but there is no space to describe them all here. Among the conclusions to be drawn from the work presented is that susceptibility to mortality in any particular species does develop in a typical manner. However, if one cause of death is removed some other cause appears, and there is little increase in total lifespan. This may suggest that ageing is in practice a unitary process, but from the data available this is by no means certain, and it may yet be found possible to effect radical changes in lifespan.

* The proceedings of this colloquium, entitled "The Lifespan of Animals", will be published in October, 1959, by Messrs. J. & A. Churchill Ltd, London.

1000-TON ELECTRO-MAGNET FOR GEORGIAN SCIENCE CENTRE

An electro-magnet, weighing 1000 tons, for the study of particles with energies a hundred times greater than those which can be obtained with the most powerful modern accelerator, will be installed at a mountain station in Georgia, U.S.S.R.

Nikolai Muskhelishvili, President of the Georgian Academy of Sciences, has announced that the construction of this station for the study of cosmic rays will be completed next year.

In an interview given to a *Tass* correspondent, Academician Muskhelishvili outlined the Georgian scientists' programme of research for the next seven years.

This programme is at present being drawn up by the Presidium and will soon be completed.

Georgian scientists will carry out research in 81 branches of science, covering 222 special problems.

Major research will be undertaken in physics, especially in the peaceful uses of atomic energy. Early next year an atomic reactor will go into operation in Tbilisi. Scientists from Armenia, Azerbaijan, and other republics will also be able to use it for research purposes.

PLASMA DYNAMICS AND MAGNETOHYDRODYNAMICS

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For some time now there has been doubt about the real temperature attained by ZETA. A recent international conference in the U.S.A. throws light on how such an error may have come about.

In early June 1958 an international conference dealing with Plasma Dynamics was held at Woods Hole, Cape Cod, U.S.A. The present account is abstracted from a fuller report which appeared in the December issue of *Physics Today*. The conference devoted much time to theoretical discussions relating to the possible excitation of thermonuclear reactions. The first session was concerned with magnetic mirror methods for producing hot plasmas. Complex fields are involved and instability is a common phenomenon in pinched-type discharges.

One contributor from Harwell questioned whether the reported Doppler effect, from which the temperature of ZETA was inferred, was in fact caused by real thermal motion or by a flow pattern. Alternative mechanisms, other than fast thermal motion were proposed by some authors to account for the observed fusion reactions in ZETA. Again, according to another author, it is fallacious to expect electric fields in a plasma to be weak because of the low electric resistance. In pinched discharges the situation is such that there exist simultaneously regions of both high and low plasma density. Because of these density differences, there can be diffusion currents, which will cause movements of both electrons and positive ions. The result of these movements is that electric fields can build up to balance the diffusion forces. Such electric fields can cause spectral line broadening which confuses the situation.

Now in ZETA the measured widths of the emission spectrum lines were tacitly taken to be due to Doppler temperature effect, but it becomes more and more apparent from these contributions that other factors can contribute to spectroscopic line widths. The real temperature may, in fact, possibly be a good deal less than that originally contemplated. This is a devastating conclusion, although one which some of us (the author included) have long suspected and even commented on.

At plasma densities of interest, the non-existence of radiative equilibrium leads to unsuspected conclusions, one of which is that impurity atoms exhibit a lower ionisation stripping than anticipated and this, too, contributes to the radiation. The conference spent a great deal of time on the consideration of the dynamics of modulated electron beams, and methods for measuring electron densities in plasmas were described.

The theory of plasma dynamics was attacked by two separate groups. The one used the statistical approach, the other the continuum approach. Thus on the one side a modified particle Boltzmann equation was invoked, and on the other the model of plasma as a fluid was tackled with the help of a Navier-Stokes equation. The large variety of possible waves in magnetohydrodynamics introduces grave difficulties in this classical hydrodynamic approach. The unusual physical conditions anticipated are emphasised by one theoretical study made for interaction of plasma-flow at a velocity of Mach 100 with a magnetic field of half a million gauss.

However, there were magnetohydrodynamic interests other than those centred on the pinched discharge to be used for thermal fusion. One session was devoted to aerodynamic potentialities of magnetohydrodynamics. It appears that when the Larmor radius in an ionised gas, flowing through a solenoid, approaches the mean free path, the direction of the current changes and can introduce a true lift. Magnetohydrodynamic force could also be used to slow down a satellite on re-entry into the Earth's atmosphere, especially if the conductivity ahead of the path is increased by ejecting forward some alkali vapour. Planetary and interplanetary magnetohydrodynamics occupied much attention also. The extent of the Sun's coronal atmosphere was computed. The existence of a powerful solar wind was inferred and this, indeed, can account for anomalies observed in connexion with the acceleration of comet tails away from the Sun. Hydrodynamic shock-waves can be expected in the corona as well as the powerful solar wind and the latter was shown to affect the shape of the magnetic-field lines coming from the Sun. Even a magnetic cosmic-ray trap can be inferred.

The astrophysical applications have also been energetically extended to the galactic scale, especially to an analysis of spiral nebulae. Evidence is accumulating of the existence of cyclotron radiation in a field of the order of 5×10^{-6} gauss and such a field has already been considered sufficient to account for the energies of cosmic rays.

It is abundantly clear that the physics of plasma dynamics, essentially the physics of conducting fluids moving in magnetic fields, has vast potentialities. This necessary resurgence of classical dynamics into so varied a field, even into the most up-to-date of nuclear atomics, is a salutary warning to the many young enthusiasts who seem to think that the only physics worth pursuing involves either vast accelerating machines, or imposing nuclear reactors, or high-energy cosmic rays, or space projectiles. Indeed, even in these so very modern fields, classical hydrodynamics is now leading the way and fewer mistakes in the past would have been made had these classical approaches been more fully appreciated. An international conference which attracted no less than forty-five eminent theoreticians actively contributing, shows that the subject has come to stay and to grow.

FIG. 1. In the primary separation plant and other chemical processes at Windscale some of the chemicals used become slightly radioactive. These, together with a little of the fission products which are of very low activity, must be disposed of. The effluent is first treated so that no harmful chemicals are discharged, then placed in holding tanks from which "safe" quantities can be dispersed in the sea. From these tanks the effluent is pumped to smaller "header" tanks where a final check is made before being discharged into the sea at high tide. The illustration shows a pipeline crossing railway and river en route to the sea.

THE SAFE DISPOSAL OF RADIOACTIVE WASTES

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Health Physics Division, Atomic Energy Research Establishment, Harwell

The increasing use of radioactive materials in medicine, industry, research laboratories, and universities, and the construction of more nuclear power stations magnify the problem of disposing of radioactive waste. The problem is complicated by the fact that the contamination in some of these materials takes millions of years to decay.

As the degree of industrialisation of a country increases, the volume and variety of waste products which arise from new industries also increase and disposal problems become more varied and more difficult. The need for new sources of power has led this country to invest in an ambitious, rapidly expanding nuclear programme, and this programme, together with the enormous parallel effort in research and development has introduced some considerable problems in connexion with the disposal of radioactive waste materials.

In a nuclear reactor the nucleus of an atom of fissile material, at present usually uranium-235, is made unstable by the absorption of a neutron, and splits into two parts. The splitting process, or fission, is accompanied by a release of further neutrons and of energy which appears in the form of heat. The smaller units (or fission products) resulting as by-products of the fission process are radioactive isotopes of a wide range of chemical elements. They are characterised by the type and energy of the radiation which they emit and by the rate at which their radioactivity decays. The half-life, the time taken for the radioactivity to decay to half its initial value, varies from a minute fraction of a second to many millions of years, and it is, of course, the longer-lived fission products which present the problem of ultimate disposal.

The world stocks of radium in 1940 were only 1000 curies. Beside this we can set the fact that the fission of one gramme of uranium-235 in a nuclear reactor produces waste products which, after allowing a year for the decay of the shorter-lived radionuclides, amount to about 500 curies of activity. Put another way, for a single power reactor the equilibrium value of the longer-lived fission products would be of the order of millions of curies.

Although the establishments associated with our nuclear-energy programme are by far the biggest producers of radioactive waste material, significant amounts of waste in gaseous, particulate, solid and liquid forms arise from hospitals, industrial isotope users, research institutes, and university laboratories.

MAXIMUM PERMISSIBLE LEVELS

It is quite clear that such an increase in the handling of radioactive materials must necessarily result in some increase in human exposure to ionising radiation. Since it is generally realised that any increase can only be harmful, we have to face up to the problem of how to reduce it to a minimum. In our natural desire to approach the ideal condition of zero exposure above the natural levels of radiation to which we have been subjected since the beginning of history, it is necessary to maintain a sense of perspective and to weigh the potential risks entailed against the advantages to be gained from the rapid development of nuclear power and the use of radioisotopes in the service of science and medicine. In setting controls we must not lose sight of the fact that the health hazards in our everyday lives are by no means negligible; but we must also not forget that one consideration is peculiar to the effects of exposure to ionising radiation—they can be passed on to future generations.

The obvious sequel to an acceptance that zero exposure is impracticable is to ask what levels of radiation can safely be allowed. A great deal of valuable information has been obtained from examination of persons who have been occupationally exposed to radiation, for example, uranium miners, X-ray equipment operators, and workers with luminous paints, and of persons exposed to radiation from nuclear-weapon explosions. Careful consideration of this information, together with that from a vast amount of animal experimentation, has led to international agreement on levels of ionising radiation which are expected, in the light of present knowledge, not to produce harmful or objectionable effects to the health and well-being of an individual occupationally exposed to radiation, at any time during his life. However, whereas persons exposed occupationally are healthy adults under medical care, the general public include persons who are not healthy, and infants and children who are more radio-sensitive than adults. For this reason it has been agreed that members of the general public should not be exposed to levels of radiation in excess of one-tenth of those accepted for radiation workers. It is possible to visualise instances where significant fractions of the population of a country could be affected by a source of radioactivity. In such circumstances, additional factors such as genetic effects and any possible increase in the incidence of leukaemia must be considered and lower levels still must be met. Although the precise evaluation of these levels is at present impossible, it would appear prudent in the case of large populations to limit radiation exposure additional to the natural levels to an amount of the order of the natural background.

OBJECTIVES

The aims in waste disposal must be twofold. Firstly, everything possible must be done irrespective of cost to make sure that these internationally accepted levels of exposure are not exceeded; experience has shown that this is possible without a complete prohibition of the discharge of radioactive wastes to the natural environment. Secondly, we should do what is practicable, having regard to cost, convenience, and other matters, to reduce the exposure levels still further.

In disposing of radioactive wastes we must ensure that there will be no direct irradiation of persons above the permissible levels, but we must also protect persons from breathing air, drinking water, or eating food that is contaminated to such a degree that these levels are exceeded by reason of radioactivity which could become fixed in the body. To this end, values have been set for the concentrations of various radionuclides which can be permitted in air and drinking-water and for the maximum amounts that can be tolerated in the body, these limits applying to continuous lifetime exposure.

It is useful to get some idea of the small amounts of material that we are talking about. Both in air and in drinking-water the permissible concentrations on a weight basis are far lower—often many millions of times lower—than would be allowed on account of chemical toxicity. Table 1 makes such a comparison for airborne contamination and for permitted levels of pollution of drinking-water.

Let us see what this means by considering strontium-90—one of the most toxic radionuclides which occurs in reactor waste materials. Suppose we take 1 curie of strontium-90, that is about 5 mg. or about one-thousandth part of this radionuclide which occurs in a typical commercial nuclear-power reactor, and dissolve this in a large swimming-pool. If a person drank one pint of this water, sufficient of the radioactive material would become fixed in

TABLE 1

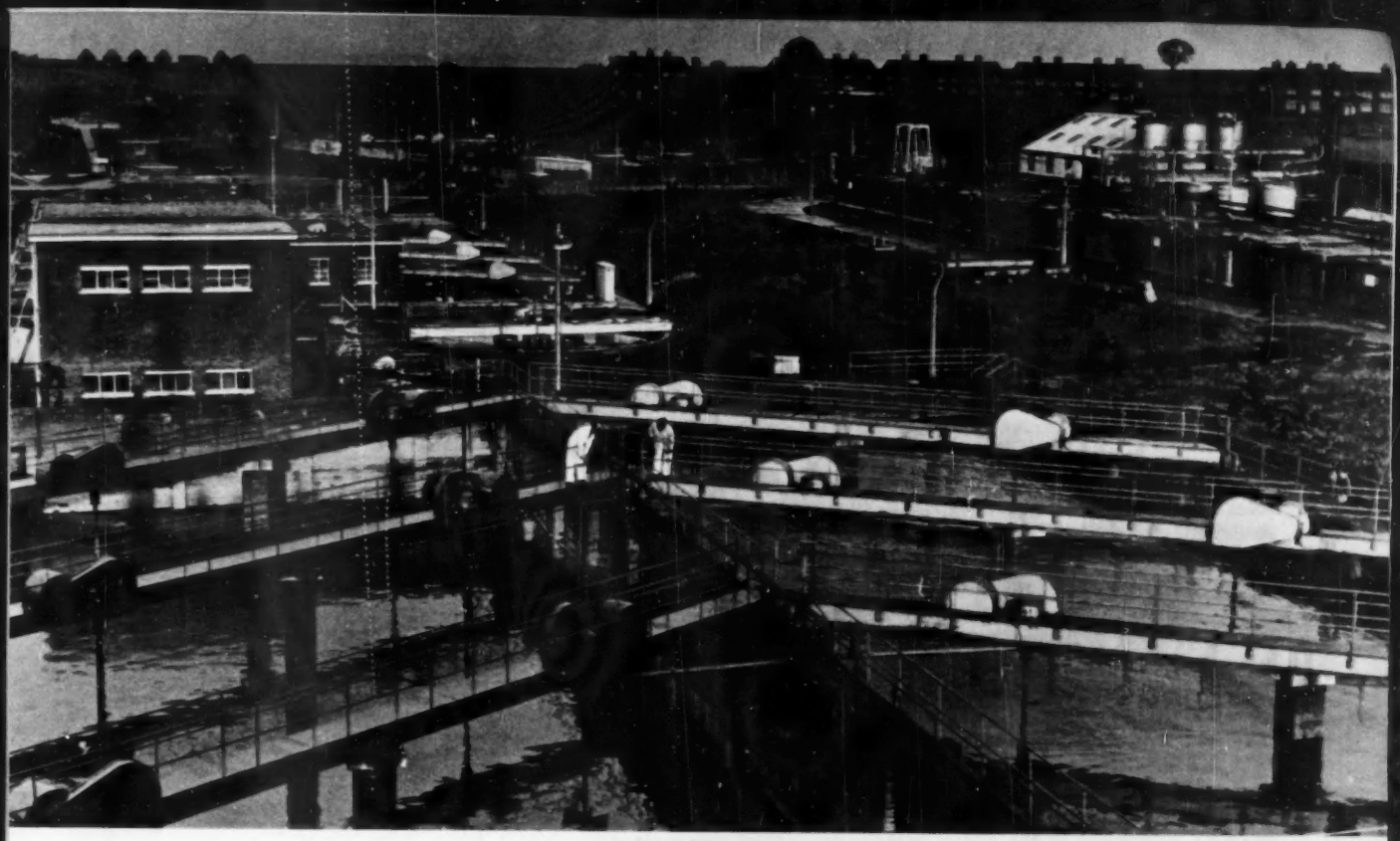
Some maximum permissible concentrations in air and drinking-water.

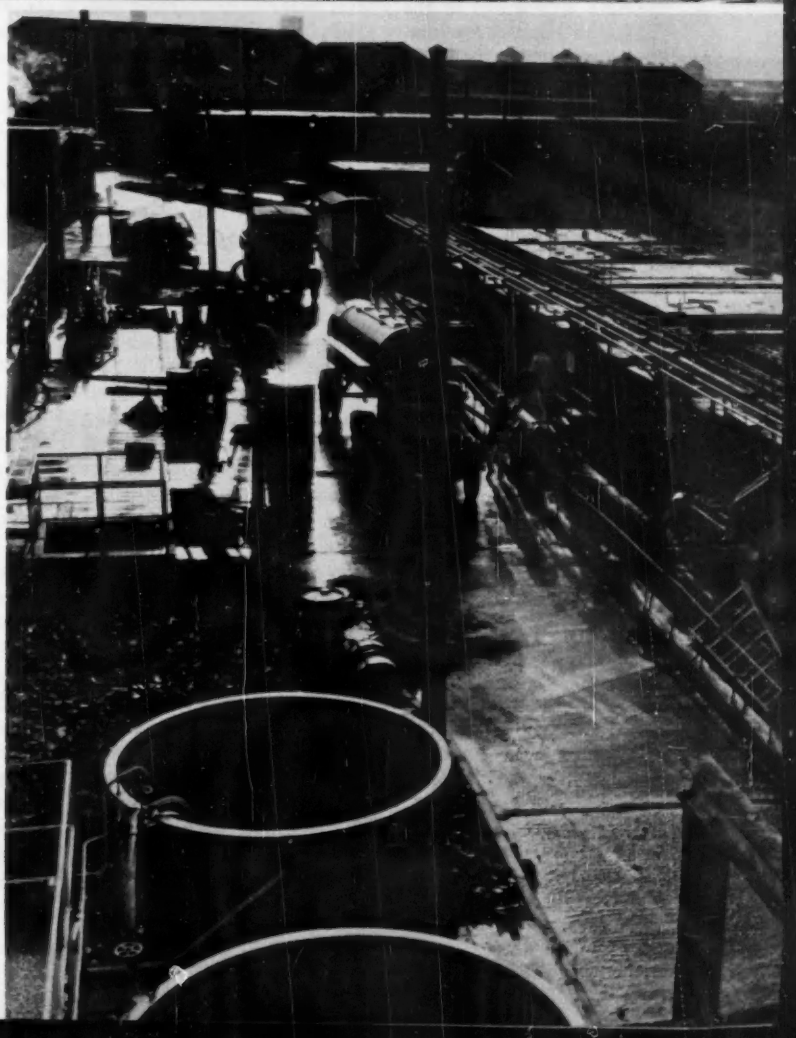
Element	*Air (μg./m.³)*		*Drinking-water (μg./ml.)*	
	Chemical Toxicity*	*Radioactive† Toxicity*	*Chemical* Toxicity*	*Radioactive† Toxicity*
Copper	—	2×10^{-2}		1×10^{-10}
Manganese	6000	2×10^{-9}	0·3	1×10^{-11}
Molybdenum	5000	1×10^{-9}	—	6×10^{-10}
Strontium	—	1×10^{-7}	—	3×10^{-10}
Radium	—	8×10^{-7}	—	4×10^{-9}
Iodine	1000	5×10^{-9}	—	5×10^{-11}

* Threshold limit values adopted by the American Conference of Governmental Industrial Hygienists, April 1958 (A.M.A. *Archives of Industrial Health*, 1958, vol. 18, p. 178.

† Maximum permissible levels of exposure for members of the general public. These are one-tenth of the levels for continuous occupational exposure recommended by the International Commission on Radiological Protection (*Brit. J. Radiology Supplement*, 1955, vol. 6.

FIGS. 2 and 3 (*left and below*). Pipeline, section from holding tanks to "header" tanks with primary separation plants in the background.





FIGS. 4 and 5 (*above and right*). The effluent plant at Harwell. In this plant dilute but radioactive effluent from the Harwell laboratories is treated by standard techniques to remove the activity before the aqueous effluent is discharged into the Thames.

(Photographs by courtesy of the United Kingdom Atomic Energy Authority)

the skeleton to give the maximum permissible lifetime radiation. The same maximum permissible condition would arise by breathing, for a lifetime, air contaminated by strontium-90 to the extent of one-hundredth of a microgramme in a volume similar to that of the Albert Hall. As a further example, the maximum permissible lifetime breathing concentration for another radionuclide, polonium-210, is only a few atoms per cubic centimetre of air.

THE LEGAL POSITION

As a prelude to examining the methods currently used for radioactive waste disposal, it is interesting to look at the legal position. Before any such waste can be discharged from establishments of the United Kingdom Atomic Energy Authority, the Authority must, under the Atomic Energy Authority Act of 1954, obtain authorisations from the Ministries of Housing and Local Government, and Agriculture, Fisheries and Food. Before granting such an authorisation, these Ministries are required to consult with such local bodies (water boards, local fisheries committees, and so on) as appear proper. After agreement is reached with the appropriate Ministries, the Authority must continue to satisfy them that the terms of the authorisation are being adhered to. The disposal of radioactive waste from premises other than those of the UKAEA, on the other hand, is subject to terms governing ordinary waste disposal; for example, provisions of the Public Health Acts (1936 and 1937), the Rivers (Prevention of Pollution) Act (1951) and the Water Act (1945). The growing use of radioactive materials has caused the Departments concerned to keep under review the possible need to make some special regulations covering waste disposal under the Radioactive Substances Act (1948).

METHODS OF DISPOSAL

In general, there are only two methods of dealing with radioactive waste materials—dispersal in the natural environment or storage. The former is attractive and fairly cheap and properly controlled dispersal is often preferable to storage. By proper control is implied a thorough assessment of all the ways in which the public may be affected and adjustment of the amount and rate of discharge and the conditions of dispersal so that no member of the public receives a greater exposure to radiation than is considered desirable. Storage is costly and often inconvenient and can hardly be regarded as a final solution, but because of obvious limitations in dispersal to the environment, long-term storage of highly radioactive liquors and solids must at present be carried out. Great care must, however, be taken to ensure that no uncontrolled escape of activity occurs to the ground or to the atmosphere.

The amount of radioactive gas or particulate matter which can be discharged to the atmosphere depends upon the degree of dilution which is obtained between the discharge-point and the point where the airborne or deposited activity may affect persons or animals; this will be determined partly by the height of emission above the ground, and partly by topographical, ecological, and meteorological conditions. Where large discharges are planned, stacks of considerable height are needed and those built to carry away the coolant air from the now old-fashioned Windscale open-circuit reactors and the effluent from the associated chemical separation plant are 400 ft. high. For small-scale uses, although such stacks may be unnecessary, gases should not be discharged lower than roof-level and the effects of down-draughts and local air-currents must be taken into consideration. The need for filtration of the effluent air depends upon the quantity and the nature of the radioactive materials concerned.

DISCHARGE INTO RIVERS

Although in some circumstances, liquid radioactive wastes may be released to rivers and other inland waters, the permissible level of discharge depends upon the use which is made of the river water and upon the number of persons exposed. Where there is no subsequent drinking of the water by humans, such as in rivers carrying large quantities of trades waste, considerable amounts of radioactivity may be safely discharged. Drinking-water, however, is not always the most important factor in determining the extent of possible hazard from radioactive pollution of rivers. Biological concentration occurs in a wide variety of aquatic vegetation, in soils and in fish, and other freshwater life, and the habits of populations must be carefully considered to assess the way in which these factors, as well as the use of the river for pleasure, agricultural, or industrial purposes may affect the permissible discharge.

The biggest release of activity to inland waters in this country occurs from three UKAEA research establishments to the River Thames and in this case the discharge is limited by the fact that the river is used as a source of drinking-water for a large population. The discharges are kept within the limits authorised by the appropriate Ministries, in accordance with basic levels laid down by the Medical Research Council, and at the water-supply intakes (and indeed at points close to the place of discharge) no radioactivity is detected in excess of the natural background.

SEA DISPOSAL

For establishments situated on the sea coast it is very attractive to allow at least some of the liquid waste to flow into the sea, and British experience over many years has shown that this can well be done on a considerable scale with negligible exposure of local or general populations. At Windscale, pipelines two miles long carry waste out to sea, and a similar method of disposal is proposed for the new Atomic Energy Establishment near the Dorset coast. As in the case of inland waters the ways in which the discharge could affect human activities must be carefully considered—the effect on fishing activities, on recreation on the beach and in the water, and on marine life which forms part of human food chains. At Windscale and off the Dorset coast, large-scale exercises involving the discharge of dyestuffs were carried out to examine the degree of dispersion which could be expected at various conditions of weather and tide.

It may happen that the limits for discharge set by such considerations do not allow more than a fraction of the liquid waste arising to be directly disposed of in this way. The impracticability of storing enormous volumes of relatively low-activity liquors makes it necessary to remove some of the activity before the liquid can be allowed to flow

to the environment, and the operation of high-efficiency chemical treatment plant provides the necessary decontamination. The disposal of the radioactive sludge produced in such plants, together with the miscellaneous solid waste, poses yet another problem.

At first sight the vast expanses of the world's oceans appear as an ideal depository for the growing amounts of such waste materials. When the utilisation of nuclear fission is at the enormous rate of 1000 tons of fissile material each year the equilibrium activity of the stored fission products will still be less than that of the total natural radioactive content (mainly potassium-40) of the oceans. However, a lot of information needs to be collected from oceanographic research and possibly from specific large-scale radiological experiments before an assessment of the radiological and economic implications can enable any decision to be taken as to the possibility of disposing large amounts of highly active wastes in this way.

Until recently it was thought that deep ocean depressions, many of them miles deep, could, on account of very slow water circulation, serve as resting-grounds for such wastes. However, some very detailed experiments (reported at the 2nd United Nations Conference on the Peaceful Uses of Atomic Energy) have shown that previous estimates on the rate of exchange of water in these depressions were probably low and the conclusion was reached that the disposal of very large amounts of activity in this way could lead to hazard in a relatively short period.

Deep-sea disposal of relatively small amounts of solid radioactive waste, encased in steel and concrete drums which are expected to have a long life on the sea-bottom, has been practised for some years by the United Kingdom Atomic Energy Authority according to authorisations granted by the Ministry of Agriculture, Fisheries and Food.

The large-scale disposal of radioactive liquors directly to the ground is not practised in the United Kingdom, but there is considerable experience of this method in America. The technique depends on the fact that much of the activity is removed from the liquor by absorption or ion exchange during downward movement through the soil. Before such a method can be implemented a great deal of exploratory work must be done to determine the suitability of a particular location with regard to the proximity of ground water supplies, percolation rates, the effectiveness of the soil for removal of activity, and the stability of the absorbed activity to leaching processes. Only few localities, however, are likely to possess the necessary combination of desirable conditions.

In cases where large amounts of radioactivity are dispersed to the environment, whether it be liquid waste to inland or coastal waters or gaseous waste to the atmosphere, it is not sufficient to rely on calculations to tell us that the discharge should be safe. Large-scale monitoring programmes are necessary to make sure that safe levels in water or in biological materials are not being exceeded. The scale of such a monitoring programme is exemplified by figures relating to the discharge of activity through the marine pipeline at Windscale. During four and a half years up to the end of 1957, some 300 samples of shore sand and silt, 700 samples of seaweed and sea-bed, and over 100 samples of fish have been collected and analyses, sometimes involving lengthy radiochemical separations, carried out.

DISPOSAL OF SMALL QUANTITIES

The methods so far described are applicable to establishments handling large amounts of radioactive materials. But what about the many users who handle only microcurie or millicurie quantities? The cheapest methods of disposing of such amounts of common radionuclides are those utilising public facilities, that is, sewers and public refuse-dumps. Since it is desirable to use such facilities where possible, realistic but safe limits must be set. The most stringent condition for the concentration of radionuclides in sewage effluents is set when the river to which they drain is used downstream as a drinking-water supply. Although exceptions can be found, in most cases it would be sufficiently restrictive to set the limits for radioactivity in the sewage effluent from the establishment at an average level of 10^{-4} microcurie per millilitre. This is equivalent to an allowance of 2 millicuries per day per 100 persons using the building and is more than adequate for most establishments.

If solid radioactive wastes are to be accepted by a local authority for disposal it is necessary for them to be segregated from ordinary waste at the place of origin so that persons engaged in the normal preliminary processes of sorting and incineration are not put to risk. If the waste is buried as soon as possible at the dump under at least five feet of refuse, where it can remain undisturbed indefinitely, it should be possible in this way to dispose of up to 100 microcurie amounts of common radionuclides.

Disposal by burial in the ground, even for small amounts of radioactive material, is really only practicable either for short-lived radionuclides, or for some with longer half-lives provided that control of the land for some years is possible. Burial sites must be carefully chosen so that no contamination is possible of underground water or of nearby agricultural produce. The depth must be sufficient to ensure that the waste will not be disturbed by future housing, sewage or road development and the importance of very full records is obvious.

Incineration of combustible radioactive waste is suitable in many circumstances, for example, in the disposal of experimental animal carcasses, but the process can be carried out safely only if the proper precautions are taken and if there is adequate control. The production of a heavy ash and the safe release to atmosphere of the gaseous combustion products are essentials. Incineration is really a matter of concentration rather than of disposal and the problem of final disposal of the ash still remains.

THE FUTURE

If long-term forecasts of nuclear-power development are correct, then within fifty years, the amount of water needed to dilute the fission products arising to the maximum permissible drinking-water level would be equal to several per cent of the water in the world's oceans. Unlimited dispersal to the environment cannot be considered as the final solution.

It is clearly safer to store high-level wastes as solids rather than as liquids and much effort is being devoted in many countries to the problem of fixing activity in solid form so that it is beyond the possibility of accidental dispersion. Incorporation in clay or sand followed by baking to a non-leachable ceramic or glass appears a promising

method, and a fused-salt calcination process is also being examined.

The development of new processing methods for irradiated reactor fuel elements, in particular pyrometallurgical processing in which the separations are carried out at high temperatures and in which the fuel is at all times in a metallic form, may assist in keeping the fission products in the most concentrated form. The technical difficulties in such processes, however, are very great and there will not be any rapid solution.

The production of nuclear power by fusion is still only a distant possibility but those responsible for the disposal of reactor waste products may see, in this direction, a future hope for a check in the continuing increase in fission product production.

EFFLUENT DISPOSAL FROM THE ATOMIC ENERGY ESTABLISHMENT, WINFRITH

The Winfrith plant and laboratories are under construction. Surface water and a small amount of purified sewage effluent from buildings in which no radioactive work is done will be discharged, by agreement, to the local rivers. All other wastes will be treated and discharged to sea.

Two identical pipelines are being installed, each of sufficient capacity to deal with the estimated daily radioactive effluents arising at Winfrith. A leak-free overland system is ensured by using a pipe-within-a-pipe system; radioactive liquid wastes will flow through the inner pipe and non-radioactive wastes through the outer annulus.

Automatic monitors on the outer stream will detect any leak from the inner pipe. The pipes are of mild steel; all welds are radiographed to Class 1 standards and surfaces are coated to reduce corrosion. Impressed cathode-cathodic protection against corrosion will be applied to both land and sea sections.

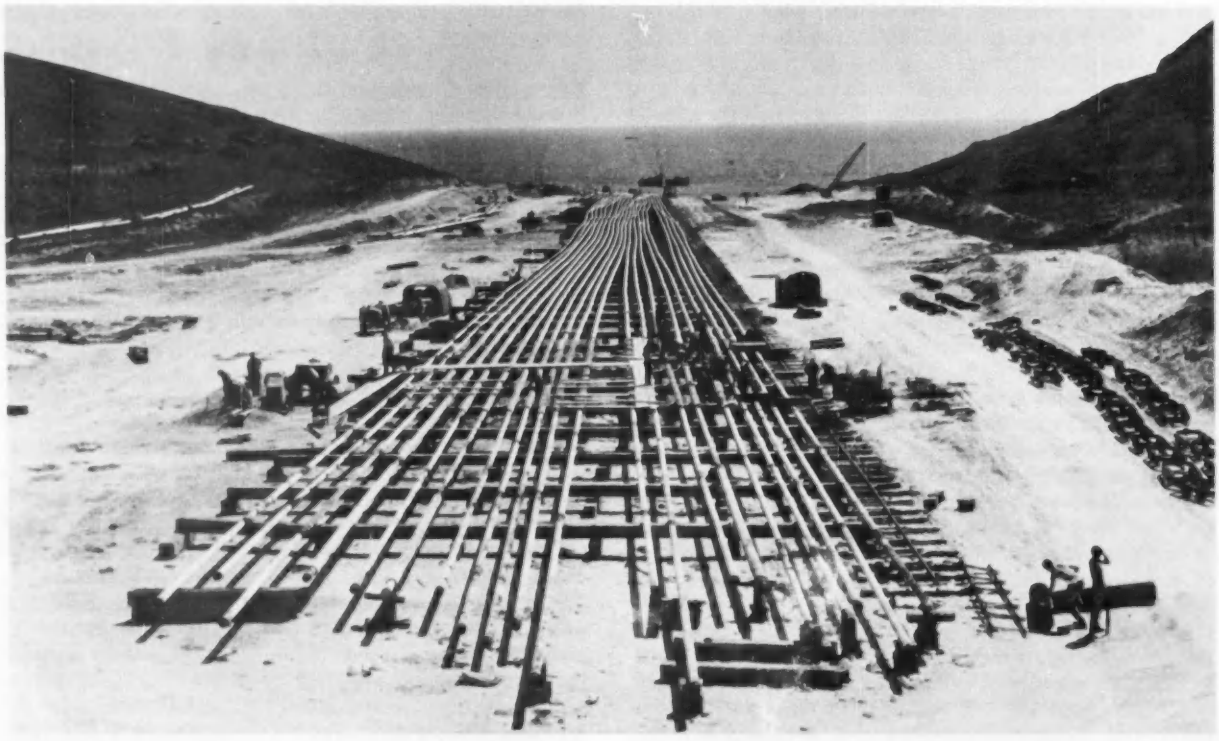
Effluents will be pumped from the main site pumphouse to break-tanks at the highest point of the six-mile route from which they will flow, by gravity, to the discharge points. The break-tanks are designed on a tank-within-a-tank principle. The final section of the overland pipeline crosses the RAC gunnery range; in this section the pipes will be buried at a greater depth to avoid damage by tanks and shells.

The radioactive effluents will be discharged through half-inch-thick welded mild steel pipelines at a point two nautical miles south of Arish Mell. The pipes will be surface protected, sheathed in concrete, and laid through channels blasted through rock reefs. The pipeline will terminate in diffusers designed to give maximum initial dispersion. The distance of two nautical miles was chosen on the basis of the results obtained during "Exercise Mermaid". Non-radioactive effluent will be discharged fifty feet beyond low water spring tides.

FIG. 6. A dual effluent pipeline is being built from the Atomic Energy Establishment at Winfrith Heath to the coast five miles away so that waste can be discharged into the sea from the site. The pipes are to be continued out two miles from the coast on the sea-bed and then brought up twenty feet to stop silting up.

Photograph of the pipes being prepared and welded together in long lengths. When the pipe is launched each piece will be winched out, the next piece rolled into position, welded on, and so on until the whole pipe is in position.

(Photograph by courtesy of the United Kingdom Atomic Energy Authority)



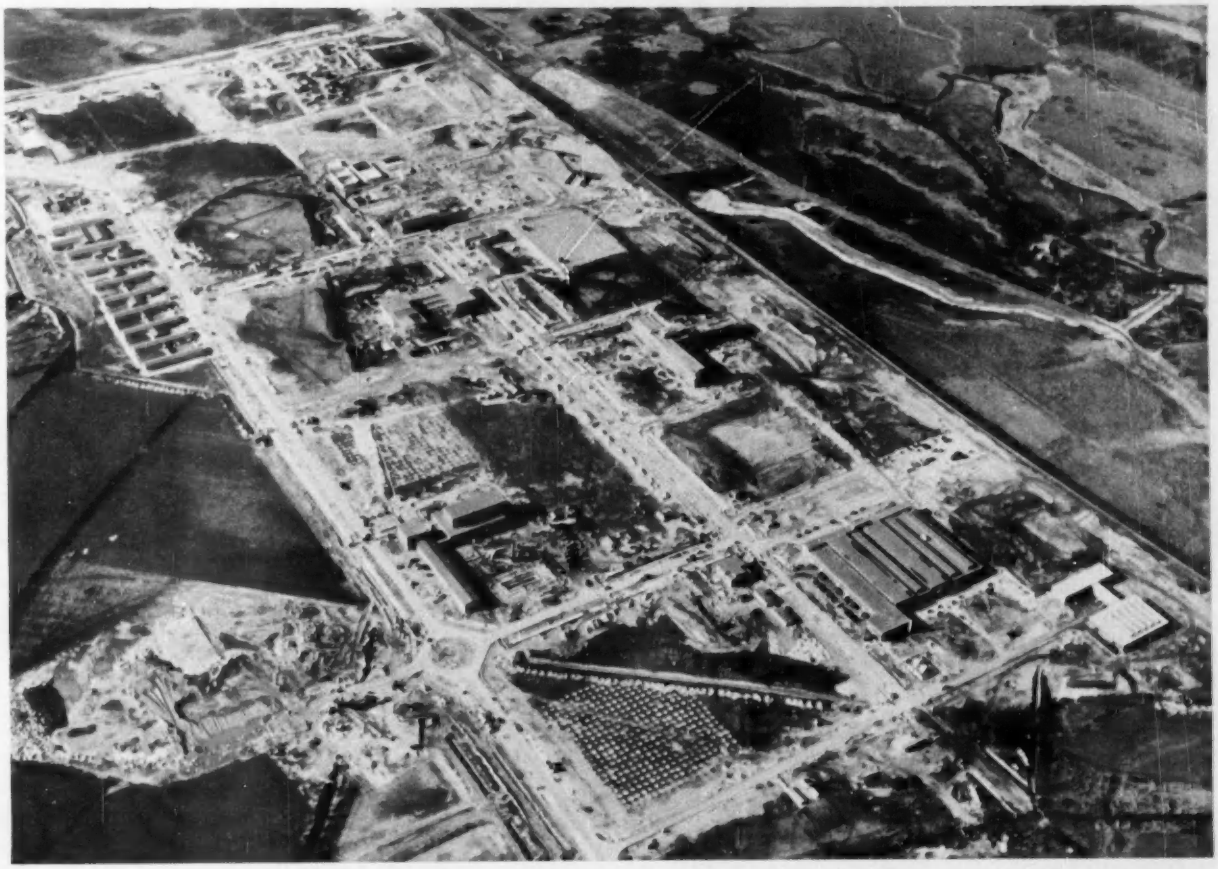


FIG. 7 (*above*). Work is proceeding at Winfrith to complete the construction of ZENITH (zero energy high temperature), a zero energy reactor designed to carry out basic studies on high-temperature graphite-moderated systems. At first ZENITH will be used to obtain data for the design of the 10-MW high-temperature gas-cooled reactor experiment (DRAGON) to be built at Winfrith as a joint European development project by the European Nuclear Energy Agency of OEEC.

An aerial view of the site in March 1959.

(*Photograph by courtesy of the Turriff Construction Corporation Ltd.*)

FIG. 8 (*right*). Photograph of the ends of some of the pipes, the launching railway, and the pile-driver with boat from where the divers are working to blast a level along the sea-bed.

(*Photograph by courtesy of the United Kingdom Atomic Energy Authority*)

BORGO A MOZZANO: AN EXPERIMENT IN ENLIGHTENED SELF-INTEREST

DR FRANCESCO FAVATI

Genoa

The programme conducted by Shell Italiana in Borgo a Mozzano is an experiment in progress through self-help. It serves as a model for technical assistance which raises a population's self-esteem along with its standard of living.

FIG. 1. General view of Borgo a Mozzano with some of the isolated outlying hamlets on the hill slopes.

One of the major problems of Italian economy today is that of raising the value of small rural holdings. About 9 million people in Italy live and work on small farms, mainly on hillside or mountain, covering more than a quarter of the country's productive surface.

These small landowners have large families, and their working capacity could play an important part in the country's economy. At present, however, they have not enough technical experience to meet the exacting demands of modern agriculture. Their earning capacity is so low that some hillside and mountain areas are in danger of becoming depopulated.

Various factors have hitherto hindered or retarded progress. Among them are the restricted and traditionalist psychology of the peasant farmers themselves, the difficulty of securing constructive co-operation among them, and shortage of capital. The main obstacle, however, is lack of technical assistance to develop the capabilities and stimulate the enterprise of the peasants themselves. The need has been for some catalyst to stimulate the latent resources of which the peasants are often unaware.

Shell Italiana decided to investigate the potentialities of small rural holdings in one of the depressed areas. After detailed study of a number of areas, the choice fell on Borgo a Mozzano, a typical district of small and scattered rural holdings in Tuscany, most of them on hilly or mountainous land, deficient in roads and in communications generally, and subsisting on poor and obsolete methods of cultivation. Most farms were operated by family units having no technical equipment and earnings were very modest.

The territory extends along the valley of the River Serchio for about 25 sq. miles, 24 of which cover agricultural and forest land. The population of 8000 inhabitants lives in sixteen separate hamlets. There are more than 1000 farms, the land producing wheat, potatoes, maize, and forage, and being thickly planted with vines and olive trees.

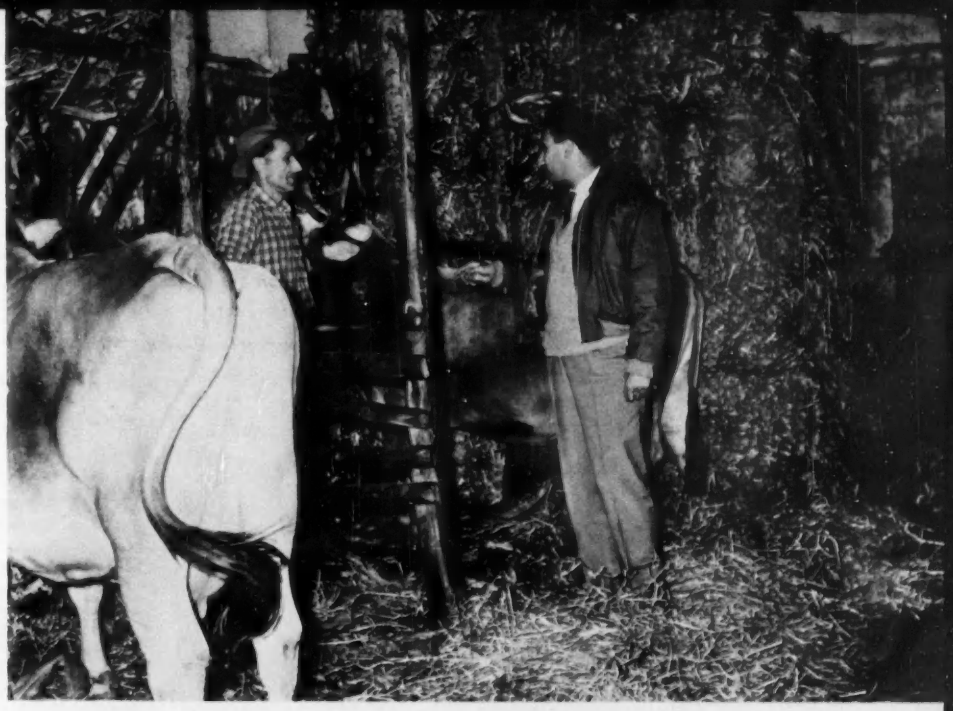


FIG. 2. The agronomist visits a farmer to give him advice on his livestock.

START OF AN EXPERIMENT

In June 1954 an agricultural expert was appointed in co-operation with Florence University to collect data about the economy of Borgo a Mozzano, and to get to know the farmers with a view to establishing beneficial collaboration. At the same time he made a complete analysis of the economical, technical, and social aspects of Borgo a Mozzano. This preliminary investigation surveyed the demographic and social environment, the type of land available, the agricultural market, and the incomes of the peasant families. This study provided the basis upon which measures for improvement were co-ordinated. The second phase of the experiment, which started in March 1955, took the form of direct technical help to the farmers.

The aim of the agronomist who conducted the experiment was to raise incomes on the local farms by increasing production, reducing cost, and establishing an efficient market policy. In this remote community he was to become the link between the farmers and a more scientific approach to the whole concept of farming. Clearly, if success was to be achieved he had to be something more than a technical expert; his own personal relations with the farming community he had come to serve were of great importance. Throughout he worked for the success of the community as a whole, avoiding making innovations without careful assessment of their economic advantage. His aim was to bring the farmers together and to stimulate co-operation among them, as well as to bring the outer

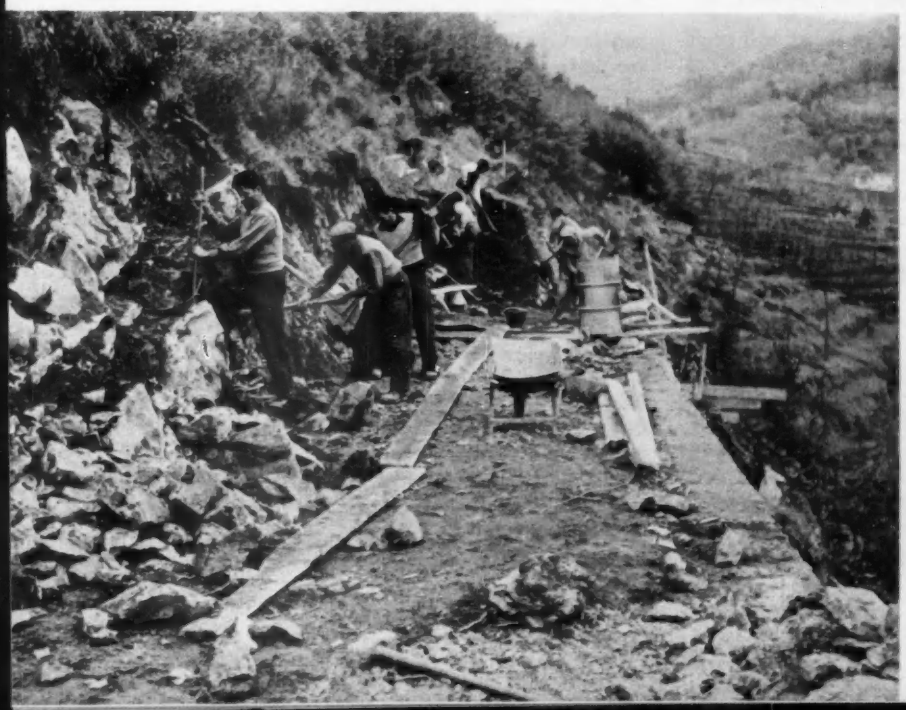


FIG. 3. The local people have put in over 6600 man-days, without pay, to build 8 miles of new roads.

FIG. 4. An example of the striking difference between the old and new crops.

world, and particularly industry, closer to them through organised contacts. As adviser, he always remained faithful to the fundamental principle of helping the farmers to help themselves. He never proposed any financial participation from the promoters of the experiment. It would have been pointless to spend large sums of money in a country where capital is lacking.

His first innovations, although limited in scope, had great psychological value and paved the way for more radical changes later. In the first year he confined himself to 10 farms; in the second year he took in 30, in the third 200, and last year 320. He concerned himself with crops, forage and wine production, and turned his attention to mechanisation, transport, and communications. To get better results from the cultivated areas, he introduced the farmers to hybrid maize, potatoes of high yield, and selected grains, growth being stimulated by more rational chemical fertilisers.

THE YIELD

As a result of the new procedure, the average production of wheat has gone up from 10·25 cwt./acre to 18·75 cwt./acre; production of maize from 9·45 cwt./acre to 16·55 cwt./acre; the production of potatoes from 43·30 cwt./acre to 82·60 cwt./acre; and forage production from 23·60 cwt./acre to 43·30 cwt./acre. New pharmaceutical crops have been introduced with appreciable economic results. The increase in produce on thirty experimental farms now averages 10% to 15% of the gross saleable production.

Efforts have been made to replace hand ploughing, practised all over the highland areas of the district, with mechanical means. The total horse-power available in the district before the experiment began amounted to 71 h.p. now it is 872 h.p. Working costs have been reduced by 80%.

Transporting produce to market had been a major problem, particularly from isolated hillside and mountain hamlets. Six hamlets have now been connected with the roads in the valley, and a total of 13·2 km. of road have been built or restored (equal to 42% of the whole district network) through the efforts of the farmers themselves. The 516 families concerned have voluntarily given 6615 days of unpaid work over two years to improve their local communications. After the roads had been built ten transport companies were established, equipped with special tractors, capable of moving the farmers' produce—a total weight of 17,220 tons a year—at a saving of 90% on the old transport costs.

Patient persuasion has changed the traditional methods of wine making, with the result that wine was treated and sold for the first time to markets outside Borgo a Mozzano. Selected poultry have replaced local breeds. The result: a total increase of 480,000 eggs.

The important part played by the women in the farm economy was recognised by the appointment of an Assistant in Rural Domestic Economy in 1957. She devoted herself to improving hygiene, child welfare, housekeeping,

FIG. 5. Suitable mechanical transport for lumber saves both time and money.

farmyard and dairy work, and working methods generally. Her advice on the best means of preserving farm produce has considerably helped to integrate the balance of the whole family farming concern.

The sum of these achievements, translated into economic terms, bring the total increase of income certified at December 31, 1958, up to 97,763,650 lire (£55,849); expenditure on technical help amounted to 19,834,728 lire (£11,334). An indication of the results obtained is given by contrasting the second year of the experiment, in which the cost of technical help (salaries, office, and consultation expenses) about equalled the increase in income, with last year, when income was five times higher than the cost of technical help.

In fifty-five months of activity in the Borgo a Mozzano district the cost of technical help has worked out at 14*s.* per acre while the total increase in net income has been £3 11*s.* 2*d.* per acre.

MODEL FOR THE FUTURE

The Borgo a Mozzano experiment was intended as a practical example of what can be done by expert guidance to raise the economic standards of underdeveloped agricultural areas. It has proved that an expert who makes himself thoroughly acquainted with the place, the problems, and the people, and who is able to gain the approval, liking, and trust of the community, can mobilise the farmers and channel their energies towards effective progress.

Much has changed at Borgo a Mozzano since the agronomist put the peasant farmer in touch with more advanced agricultural techniques. Above all, the spirit of the people has changed; and this is the most important achievement. No difficulty proved too great for them to overcome, once their trust had been gained and their knowledge increased.

Borgo a Mozzano has set a pattern for other similar enterprises being undertaken by national or international bodies. Mention might be made of the experiment being carried out by the OEEC in Sardinia over a wide area, including thirty-six districts, and the one being undertaken by the UNNRA-CASAS and the CEPAS in collaboration with UNESCO in Abruzzo, in an area covering thirteen districts.

More than 41% of the Italian population is dependent upon agriculture, so that any scheme which raises the standard of living of this considerable section of the community benefits trade in general by stimulating the purchase of consumer goods. For Shell Italiana then, Borgo a Mozzano was partly an experiment in enlightened self-interest. As other examples of stimulating a prosperous agriculture, mention might be made of the pilot farm in France and experiments in Portugal and Holland.

Moreover, in agricultural research centres in the United Kingdom, on the Continent, and in the United States and Venezuela, scientists are continuously at work perfecting new fertilisers, insecticides, and weed-killers to help the farmer raise food production and fight the pests that threaten his crops, and, incidentally, his health.

MARKET RESEARCH ON SYNTHETIC DETERGENTS

N. PILPEL, Ph.D., B.Sc.

Over 200,000 tons of synthetic detergents are now being used every year in the United Kingdom as alternatives to soap and soap products. Of this total, somewhere in the region of 170,000 tons are being employed in the home for such purposes as washing clothes, crockery, and dishes, cleaning paintwork, removing stains from carpets, and shampooing hair. The remainder is being used in commerce and industry, mainly for washing, cleaning, and scouring of textiles, but also for a host of other purposes which include lubricating machinery, recovering minerals from their ores, extinguishing fires, destroying agricultural pests, and fabricating commodities such as paints, polishes, cosmetics, inks, paper, and adhesives.

Since the annual consumption of soap and soap products is somewhere in the region of 350,000 tons, it follows that synthetic detergents now account for approximately two-fifths of the total consumption of this type of material in the United Kingdom.

Although the earliest synthetic detergents had been prepared as long ago as 1831, and had been used in industry in small quantities from about 1850 onwards for wetting wool and dispersing dyes, it was not until the late 1930's that the synthetic detergent industry really began to develop in this country. Prior to the outbreak of the Second World War, less than 500 tons of synthetic detergents had been consumed annually in the United Kingdom, mainly by industry, but also to some extent in the form of "soapless shampoos", which had appeared on the domestic market in 1935 and 1936.

A year after the war ended, in 1946, the total consumption of synthetic detergents (as marketed*) was somewhere in the region of 35,000 tons. Since that time the growth of the industry has been extremely rapid and consumption in both the domestic and in the industrial fields more than quadrupled in the period of ten years from 1946 to 1956. This is shown graphically in Fig. 1.

THE DOMESTIC MARKET

The Introduction of Detergents

It was undoubtedly the shortage of natural oils and fats during the period 1939 to 1950† which stimulated sales of synthetic detergents in this country and opened up the possibilities of employing them permanently as substitutes for soap in the home. The oils and fats which are the raw

* Synthetic dish-washing powders are included at 10% of their marketed weight. These were inferior products which have now disappeared from the market.

† Soap rationing ended in September 1950.

U.K. CONSUMPTION OF SYNTHETIC DETERGENTS. 1946–1957.

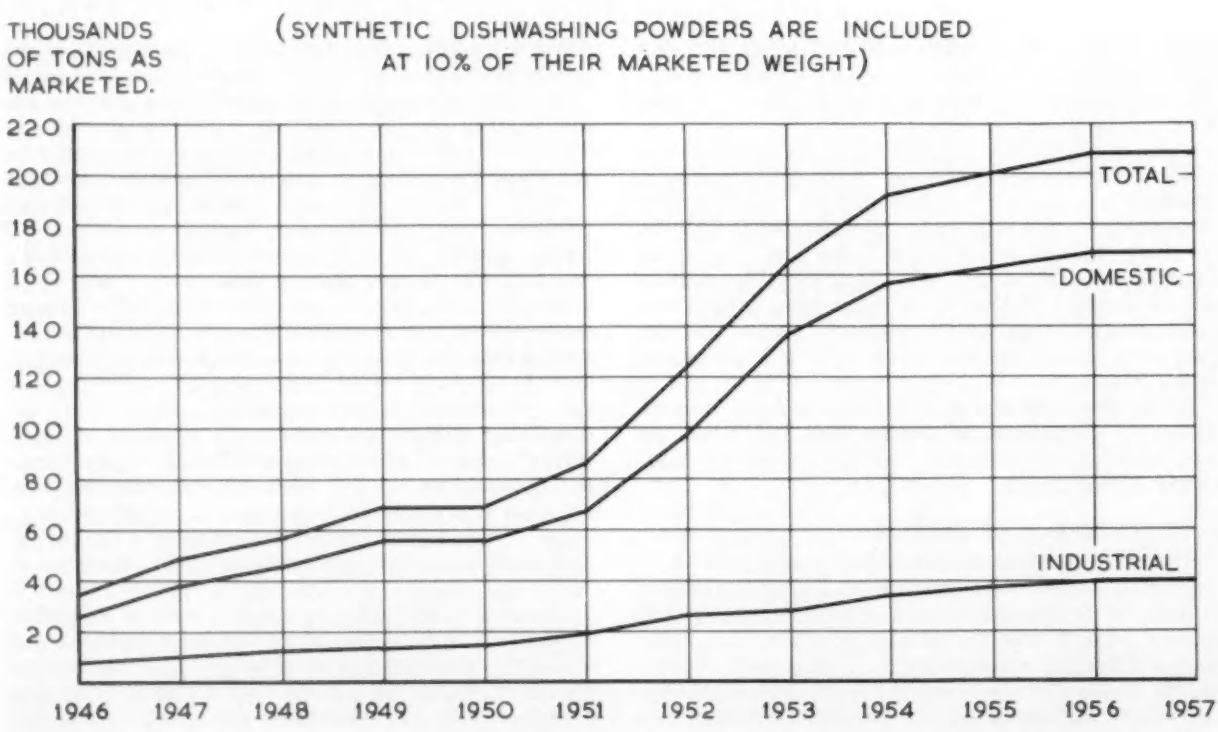


FIG. 1

materials from which soap is made are also the raw materials for margarine, salad creams, and other foodstuffs, and since these clearly have first claim, it is not surprising that a considerable demand developed during the war for substitutes for soap which were not dependent on the very scarce supplies of natural oils and fats.

To meet this demand, numerous detergent preparations were introduced which were based on chemicals derived from petroleum and from coal. Many of these were, by present standards, very inferior products, and were only tolerated because supplies of ordinary soap were so short. But a number of liquid detergents were satisfactory, provided they were used for the purpose for which they had been designed. They were satisfactory for washing dishes, removing grease, and laundering fabrics which were only lightly soiled, and although at that time they were considerably more expensive than soap products, sales of liquid detergents by 1946 amounted to about 22,000 tons annually.

Today the number of individual washing products based on synthetic detergents is very much less than it was at the end of the war. But the total quantity used, as well as the quality of the products, is very much higher, and synthetic detergents are now permanently established as substitutes for soap in the home for very many washing purposes.

Liquid and Powdered Detergents

Synthetic detergents are sold on the domestic market in two main forms—as liquids and as powders, and the latter are, at the present time, by far the most important, accounting for over 90% of all domestic sales. The position in 1946, however, was different, for at that time liquid detergents predominated and accounted for over 80% of sales. The rest was made up by the synthetic dish-washing powders and by a number of other powders which, however, differed in important respects from the types which are available today.

The main reason why liquid detergents have gradually been displaced by the powders is due to the fact that liquid detergents are light duty washing products. They consist of the active chemical diluted with water and although they are good for removing grease and small amounts of dirt, they do not possess the ability to clean heavily soiled articles where the bulk of the dirt is in solid form.

It was not, in fact, until the late 1940's and early 1950's, when general-purpose detergent powders began to come on the market in large quantities, that the synthetic materials became definitely competitive with soap and soap products. These powders contain about 20% of the active chemical, together with phosphates, silicates, and other substances, and they can be used for every type of washing in the home, light or heavy, with the sole exception of personal washing.

Thus liquid detergents have gradually been relegated to specialised functions, such as washing up crockery, cleaning carpets, and rinsing delicate fabrics, while the powdered products have captured a proportion of the market previously held by bar washing-soap and soap powders.

Competition between Brands

As far as the general consumer is concerned, it matters very little whether a washing product is based on soap or on a synthetic chemical. From the technical point of view, there is little to choose between a good-quality soap powder and an all-purpose detergent powder. It is true that the latter work better in hard water since they do not produce scum. They are also rather better in coping with large quantities of grease, as, for example, in washing dirty dishes. On the other hand, detergent powders tend to be slightly harder on the hands than soap powders, and they are also, on the whole, slightly more expensive. By and large, however, soap powders and detergent powders may be considered as equivalent products, since both are versatile, efficient, easy to handle, and reasonably priced.

Following the widespread adoption of synthetic detergents there has been a marked decrease in the number of firms supplying them, and at the present time, two firms, namely Unilever and Thomas Hedley, compete for over 95% of all detergent sales. But these two firms are also the biggest suppliers of soap and soap products in this country.

The result has been that competition, which at the beginning tended to be between soap products on the one hand and synthetic detergents on the other, has, in the last few years, tended increasingly towards competition between different brands of washing-products in general. The rate at which synthetic detergents have been displacing soap products has decreased, and indeed, it seems that a point of balance is rapidly approaching where consumption of the two types relative to each other will become more or less constant. This is shown by the market flattening since 1955 of the curves in Fig. 1.

TABLE 1

Estimate of the Share of the Domestic Powder Market held by the Main Soap and Detergent Brands (to the nearest 5%, after Puplett)

Brand	*Winter 1951*	*Spring 1953*	*Winter 1954*	*Spring 1956*
	%	%	%	%
Persil	35	40	35	40
Oxydol	20	15	5	5
Rinso	15	10	5	5
Tide	20	25	15	20
Surf	—	†	10	5
Daz	—	†	15	10
Omo	—	—	10	10
Dreft	5	5	†	†
Miscellaneous	5	5	5	5
Total	100	100	100	100

† Less than 5%

The changing pattern of sales of the main brands of detergent powders in the last few years may be seen by reference to Table 1. This table shows how, as a result of advertising, sales promotion, and improvements in quality, the different brands have competed with each other on the domestic market. It also gives an idea of how the detergent powders have displaced the powders based on soap. Thus, in 1951, approximately 70% of the washing-powder market was held by soap powders, but by 1956 this figure had

TABLE 2

Dates of Launching some of the Main Detergent Powders

Brand	*Dreft*	*Tide*	*Surf*	*Daz*	*Omo*
Date of first test marketing	May 1947	May 1949	—	Nov. 1952	—
Date of launching	July 1948	May 1950	Sept. 1952	April 1953	May 1954

TABLE 3

Consumer Survey on Soap Powders and Detergent Powders

The better product	*For Woollens*		*For Whites and Coloureds*		*For Dishes*	
	1948	*1951*	*1948*	*1951*	*1948*	*1951*
	%	%	%	%	%	%
Synthetic Powders	14	61	6	47	7	67
Soap Powders	46	25	70	40	53	17
No difference and don't know	40	14	24	13	40	16
Total	100	100	100	100	100	100

dropped to about 50%. It is interesting, on the other hand, to notice that although the overall trend has been for detergent powders to displace soap powders, sales of one soap powder, namely Persil, have actually increased. In 1951, this held about 35% of the market. Now it holds about 40%. So the maker's claim that Persil is the most widely used of all washing-powders is quite justified. Of the washing-powders based on synthetic detergents, Tide, made by Thomas Hedley & Co., has been the most widely used, and at the present time takes first place with about 20% share of the market in washing-powders.

Quality, Price, and Advertising

Many methods have been employed by the manufacturers for promoting sales of their products. The present position with synthetic detergents has arisen from a combination of their high technical quality, their price, and the extent of the advertising that has been devoted to individual brands by the makers. It is probably true to say that although synthetic detergents would have achieved their present position on quality and price alone, the process would have taken a good deal longer had it not been for the advertising that accompanied it.

In order to assess the effects of these three factors—quality, price, and advertising—on the sales figures for synthetic detergents the manufacturers carry out a great deal of market research. This is designed to answer such question as: How do synthetic detergents compare with soap products? Are they equally satisfactory for all types of washing? What is their effect on the hands of the user? Would more people switch to them if their price was reduced? Does the issue of a free voucher or a free packet of detergent have a significant effect on a consumer's subsequent buying-habits?

Many of the present brands were initially launched on a restricted scale to give manufacturers an opportunity of finding the answers to such questions before the product was launched on a national scale, and this is indicated by some dates in Table 2. It is seen that in the case of Dreft and Tide, the period of test marketing lasted for about one year, in the case of Daz about six months.

Market research does not cease with the end of the test period, however. It remains an integral part of sales promotion and, indeed, plays a major part in developments. It was market research that disclosed the technical weaknesses of the synthetic detergents of the immediate post-war period and which stimulated the developments which have led to the present products. Thus consumer surveys indicated that in 1948 there was a marked preference by housewives for soap powders for washing woollens, white and coloured articles, and dishes, but that by the end of 1951 there had been a swing in favour of the synthetic powders. Some relevant figures from these surveys are given in Table 3. Again market research showed what sort of demand there was likely to be for detergent powders with slight bleaching properties which would improve the whiteness of cotton articles on boiling. A careful study of the public's answers to questions concerned with the whitening properties of existing brands disclosed that a need for such products existed and brands such as Surf and Daz were introduced to meet it.

The same type of research enables the manufacturers to plan the most effective ways of increasing sales of their products. Is it, for example, better to reduce the retail price of a product, thereby decreasing the profit margin, or to spend the equivalent amount of money on advertising and the issue of free samples? The cost of advertising is usually much less than the cost of a significant reduction in retail price, but at what point does further advertising cease to affect sales? It is at this point that a price reduction may become justified.

Up to the end of 1954 there had been very little competitive price-cutting by the rival manufacturers of synthetic detergents. The price of a 16-oz. packet of Tide had remained constant at 1*s.* 11*d.* for nearly four years. Surf and Daz, which had come on to the market in 1952 and 1953 respectively, had cost the same and the growth of sales of all the brands had been achieved very largely by advertising and by the issue of coupons (some figures in Table 4 give an estimate of the amounts spent in the Press, on outside hoardings, and in the cinema for some of the main brands between 1952 and 1955).

Since the end of 1954, however, there has been a greater tendency to employ retail price-cutting as a means of increasing sales and prices have fluctuated over the last three years. The prices of the 16-oz. packets of Surf and Omo were reduced to 1*s.* 8*d.* in November 1954, and shortly

TABLE 4

Estimated Advertising in the Press, Outdoor, and Cinema for some of the Main Brands in thousand £'s (to the nearest £10,000, after Puplett)

Brand	*1952*	*1953*	*1954*	*1955*
Dreft	30	—	100	90
Tide	400	630	640	670
Surf	130	510	550	580
Daz	1	480	580	610
Omo	—	—	460	630

TABLE 5

Suppliers of the Main Domestic Washing Products (excluding Soap and Shampoos)

	Unilever	*Thomas Hedley*	*Co-operative Wholesale Society*	*Colgate-Palmolive-Peet*	*Domestos*	*Bibby*	*Irano Products*
SOAP FLAKES	Lux	Sylvan	Crysella	—	—	—	—
SOAP POWDER	Persil Rinso	Oxydol	Solvo	—	—	Clo-zone	—
LIQUID DETERGENT	Quix	—	Laundene	—	Stergene	—	By-Prox (Scotland only)
GENERAL-PURPOSE DETERGENT POWDER	Surf Omo	Tide Daz Cheer Fairy Snow	Spel	Fab	—	—	—
LIGHT DUTY DETERGENT POWDER	—	Dreft	—	—	—	—	—
SPECIAL PRODUCTS AND SCOURING POWDERS	Vim	Mirro Flash	Pulvo	Ajax	—	—	—

afterwards Tide and Daz were reduced to 1*s.* 10*d.* At the same time changes were made in the prices of the main brands of soap powders.

The issue of coupons and free samples to a proportion of consumers makes it difficult to assess the exact effects that price changes have had on sales. Certainly the nominal retail price in itself does not control how a particular brand will sell at the expense of other brands. It seems that a price-cut is more effective if sales are already high, so that a small cut on a widely used brand produces a bigger increase in sales than a somewhat larger cut in the price of a brand which is less widely used. This is shown by the sales figures for Tide and Surf between the end of 1954 and the middle of 1956 (Table 1), when the former rose and the latter fell, despite the fact that Tide was selling at a higher price.

THE INDUSTRIAL MARKET

A few remarks may now be made on the sale of synthetic detergents for industrial purposes.

In 1946, industry was using approximately 9000 tons of synthetic detergents annually, and at the present time is using about 40,000 tons as marketed. Sales to industry have thus gone up considerably and, like domestic sales, have more than quadrupled in a period of about ten years. The proportion of the total, however, has not altered greatly and over the period industrial sales have remained more or less constant at about 20% of the total sales. This is illustrated by reference to Fig. 1.

It has already been mentioned that synthetic detergents are employed in industry not only for washing purposes but also for a host of other applications. The number of different products is greater than on the domestic market and the number of firms involved is also greater.

Most of the synthetic detergents used in industry are supplied directly by chemical companies, such as Shell Chemicals, ICI, and Marchon Products. No up-to-date figures are available, but it has been estimated that in 1952 65% of the industrial market was held by Shell Chemicals, 17% by ICI, 12% by Irano Products Ltd, and 2% by Marchon Products Ltd. Since that time Unilever and Thomas Hedley & Co., who are the main suppliers of domestic detergents, have also entered the industrial field and competition between them and the chemical firms has increased.

Although this competition has been promoted by means of advertising, this has been on a substantially smaller scale than on the domestic market. On the domestic market the cost of advertising, including the cost of coupons and free samples, has been in the neighbourhood of 10% of turnover over the last few years.

The corresponding figure for the industrial market, however, has probably not exceeded 2–3%. The reason is that in industry the number of potential customers for a detergent product is relatively small, so that personal contact between seller and buyer plays a much bigger part than in selling to the general public.

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PRIMITIVE MAMMALS OF SOUTH AMERICA

PHILIP STREET

FIG. 1. Tamandua Ant-eater (*Tamandua tetradactyla*) in Paignton Zoo, July 1956.

The egg-laying monotreme mammals and the pouched marsupial mammals of Australia and the neighbouring islands have never lacked publicity. By contrast the primitive mammals of South America, equally interesting in their way, and equally exclusive, have received much less attention. Over the past few years, however, visitors to British zoos have had good opportunities to familiarise themselves with South American mammals, several large consignments having arrived from a continent that had for some time been neglected by animal collectors.

The Edentates (toothless mammals), which, except for certain species that have penetrated to the southern parts of the United States via Central America, are found nowhere else in the world, are probably the most primitive of all existing placental mammals; however, as with so many primitive animals, they show a remarkable adaptation to specialised modes of life and their low position is not at once obvious. The Edentates are a small group, comprised of two kinds of sloth, three ant-eaters and a dozen or so species of armadillo. Although designated toothless, only the ant-eaters are entirely without teeth. Sloths and armadillos do have simple molar teeth, but they have no teeth in the front of the mouth. In earlier times the South African aard-vark or ant-bear, and the pangolins or scaly ant-eaters of Africa and Asia were included in the same group, but are now classed separately.

THE SLOTHS THAT LIVE AT HALF-SPEED

All the Edentates exhibit unusual features both of structure and of mode of life, but it is perhaps the sloths that are the most unusual members of the group. The development of prehensile tails by which they can suspend themselves from branches is a notable feature of a large proportion of South America's arboreal mammals. But the sloths have evolved a completely different method of suspension, and their tails are reduced to rudimentary stumps. They are

FIG. 2. Great Ant-eater (*Myrmecophaga tridactyla*) in Chessington Zoo, October 1956.

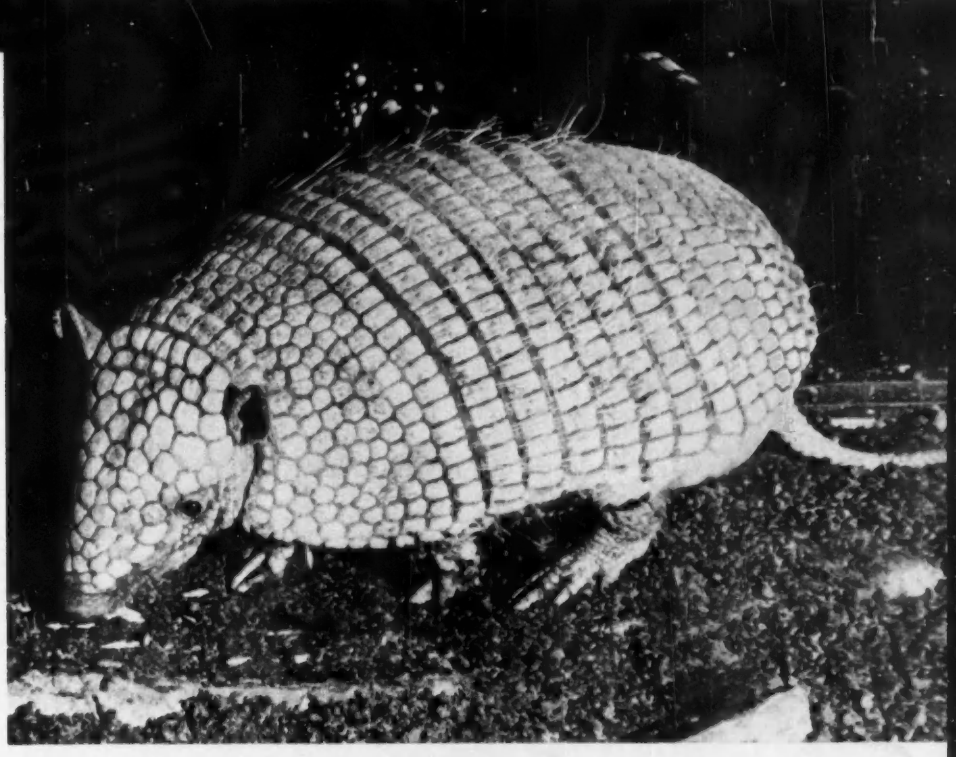


FIG. 3. Six-Banded Armadillo (*Euphractus sexcinctus*) in Bristol Zoo, July 1956.

the only mammals that have perfected a method of living upside down, suspending themselves from horizontal branches by means of slender but strong limbs with long, curved claws that function as hooks. In trees they are very sure-footed, but on the ground they can only progress with difficulty at a very slow pace, placing each front foot forward in turn and dragging the body slowly and laboriously after it. This, however, is no great handicap because in the wild state a sloth seldom comes down from the trees.

The names "two-toed" and "three-toed", by which the two kinds of sloth are distinguished, refer to the number of toes on the front feet, both species having three toes on the hind feet. The two-toed sloth (*Choloepus didactylus*) is the one generally seen in zoos. It is larger than the three-toed species (*Bradypus tridactylus*), and can be very aggressive unless tamed: with its simple peg-like teeth it can inflict a painful bite. These teeth are blackish and completely lacking enamel. In consequence they are subject to constant wear, but to compensate for this they grow throughout the animal's life.

As an adaptation to its peculiar mode of life a sloth's hair hangs in the opposite direction to that of other mammals to allow rain to run off. The individual hairs, too, are grooved, and in these grooves minute green algae establish themselves and impart a greenish tinge to the whole fur. It is assumed that this gives a valuable protective function, helping to camouflage the sloth as it hangs in the trees.

Although sloths hang upside down as they move about feeding on leaves and fruits, which they generally do at night, they usually rest in a more or less upright position, clinging close to a branch with the head bent forward on to the chest. In this position and with their greenish colouring they are extremely difficult to detect. In fact they were for a long time considered to be very rare animals, as they were seldom seen.

Their ability to conceal themselves so effectively must have played a large part in their survival, because their movements would be far too slow to ward off attacks by predators. Against man, the major enemy of so many wild animals, their very slowness is their main defence. Native populations everywhere have an instinctive fear of slow-moving creatures, whether slow loris in Asia, horned chameleon in Africa, or sloth in South America. In consequence it is a deeply ingrained tradition that no sloth shall be killed or harmed in any way.

The sluggishness of a sloth's movements seem to be but a reflection of a sluggishness of its whole metabolism. Its body temperature is said to fluctuate normally between 85°F and 91°F, and may fall as low as 75°F. It can go for long periods without eating, and its food takes up to seven weeks to pass right through the gut. Defecation may occur only once a week.

ADAPTATION TO A DIET OF ANTS

In outward appearance and behaviour there is little to suggest that the lesser or tamandua ant-eater (*Tamandua tetradactyla*) is at all closely related to the sloths. Like them, it is arboreal, but for suspension from branches it relies upon its well-developed prehensile tail. Hanging securely by this alone, it tears bark with its powerful chisel-like claws in order to expose the ants on which it feeds. The middle claw on each of the front feet is so large that when the animal comes down to the ground it has to walk on the outer edges of these feet.

Like all ant-eaters, it is completely without teeth. Its tongue is long, thin, and tubular, and is liberally moistened with sticky saliva to mop up the ants as they are uncovered. The long muzzle ends in a tiny mouth just big enough to let the tongue pass through it. Each time after the tongue has been withdrawn the ants adhering to it are wiped off by the lips as it is protruded again, and then swallowed.

The tamandua is an alert, lively animal, capable of mopping up ants at great speed. It is about the same size as a domestic cat. In captivity it is easily tamed and may become quite affectionate.

FIG. 4. Two-Toed Sloth (*Choloepus didactylus*) in Paignton Zoo, July 1956.

FIG. 5. Rat-Tailed Opossum (*Metachirus nudicaudatus*) in Paignton Zoo, October 1956.

The great ant-eater (*Myrmecophaga tridactyla*) is a much larger terrestrial animal. When fully grown, it has a body and head length of about four feet, and the enormous bushy tail, which is not prehensile, is of similar length. The claws on the front feet are even more developed than those of the tamandua, and are used to break up ant and termite nests, the tongue then being used to mop up the ants and termites in the same way as the tamandua uses its tongue.

Specialised feeders are often difficult to maintain successfully in captivity owing to the difficulty of getting them to accept substitute foods. But both the tamandua and the great ant-eater can be weaned off ants quite easily, and will thrive on a diet of minced meat mixed with egg and milk, using their tongues to lap it up.

In some respects the pygmy ant-eater (*Cyclopes didactyla*) is the most interesting of the three species because in its behaviour, though not in its structure, it forms a link between the ant-eaters and the sloths. It has a short muzzle and a wide mouth, which suggests that it is a less specialised feeder, probably eating a variety of grubs and adult insects. Little, however, is really known about its feeding habits. It is an arboreal animal, about the size of a squirrel, and like the tamandua it relies upon a prehensile tail to anchor it to the branches on which it sits. Having chosen a spot it can remain there quite motionless for hours with its body bolt upright and its front feet, complete with the sharp claws typical of the group, held above its head. It is this stillness, and the sluggishness of such movements as it makes, that are so strongly reminiscent of the sloths. Like these, it is probably more abundant than is generally realised, but it is extremely difficult to detect among the trees. Complete lack of movement is certainly one of the finest methods of camouflage for arboreal animals.

Unfortunately, we are unlikely to see this unusual animal in captivity because once it has been caught it refuses to eat, and will pine away and die unless it is released. Only two specimens have ever reached the London Zoo. One arrived in 1854 and lived for two days; the other came in 1858 and survived for four days. No more are likely to be acquired, unless the secret of enticing them to eat is discovered, because it is now the policy of most zoos not to obtain any animal unless there is a good chance of keeping it alive and in good health and spirits.

HEAVY ARMOUR REPLACES FUR IN THE ARMADILLOS

Animal classification is based on fundamental internal structure and not on superficial appearances, though of course these sometimes provide valuable additional data. Certainly there is little external suggestion that armadillos are at all closely related to the sloths and the ant-eaters. With their complete body armour of bony plates overlaid with horn, a feature unique among mammals, there is something reptilian and primitive about their appearance, for although they are mammals their fur is reduced to sparse outgrowths of hair projecting from between the plates.

Armadillos have simple peg-like molars similar to those of the sloth, and a long tongue like the ant-eaters', but their diet is more varied than that of either group, and includes all kinds of small invertebrate animals as well as fruits and other plant food. Judged by their numbers they are a flourishing group of animals. The nine-banded armadillo (*Dasypus novemcinctus*) is in fact not only becoming more abundant in Central and South America but is steadily becoming established and spreading in some southern parts of the United States.

There is a popular idea that all armadillos are able to roll up into a defensive ball like woodlice, but it is only the Brazilian three-banded species (*Tolypeutes tricinctus*) that has a sufficiently flexible shell to enable it to do this. Significantly this species is usually abroad feeding during the daytime, whereas the other species are in the main nocturnal. Armadillos vary in size from the little fairy armadillo (*Chlamyphorus truncatus*) with a maximum length of about six inches, to the giant armadillo (*Priodon gigas*) which may be four feet long.

How primitive are these Edentates, and where do they belong in the mammalian hierarchy? These questions are always difficult to answer exactly. They are certainly among the lowest of existing placental mammals and perhaps they represent the earliest group still surviving. In considering existing animals in any group, though, it must always be realised that in the main they probably represent the last members of the group to be evolved, and are therefore almost certain to be much more specialised and adapted for their particular modes of life than earlier members that have subsequently become extinct. And as we have seen, all the existing Edentates are particularly well adapted to the lives they lead both in structure and behaviour.

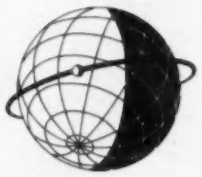
SOUTH AMERICAN MARSUPIALS

South America is the only part of the world where both marsupial and placental mammals have developed and remained together. In Australia and neighbouring islands the marsupials have developed out of contact with placental mammals, and in other parts of the world where they once existed together, marsupials have long since become extinct.

These South American marsupials form a distinct group not closely related to any of the Australian groups. They are called opossums, and there is a certain amount of confusion because the members of one of the Australian groups most nearly related to them are also sometimes referred to as opossums. The true or American opossums (*Didelphiidae*) are all carnivorous, feeding on insects and other small animal life, and have long, scaly, prehensile tails, in contrast to the Australian opossums which have big bushy tails and are in the main vegetarian. Like most of the Edentates, they are nocturnal and arboreal.

Besides being the only living marsupials outside Australasia the American opossums are also distinguished as the only pouched mammals without a pouch. In the majority of species the pouch is either completely suppressed or reduced to two rudimentary folds of the abdomen, so that the teats to which the minute new-born young attach themselves are exposed. When they have developed sufficiently to detach themselves from the teats they ride about on their mothers' backs, clinging with claws and prehensile tail.

GEOPHYSICS AND SPACE RESEARCH



By ANGELA CROOME

Commonwealth Space Plans—and Satellites

This month there is to be a two-day Commonwealth space symposium in London. It will immediately precede the tenth congress of the International Astronautical Federation, which is meeting here this year. The tempo of several Commonwealth countries' space interests has increased since the COSPAR meeting in March which some attended. National space committees affiliated to the national academies of science are being formed.

Canada was the first Commonwealth country to form a space research committee. This took place on June 4 at a meeting of the National Research Council of Canada, only three months after the formation of such a body in Britain. Dr D. C. Rose of the National Research Council, who is distinguished for his work on cosmic rays, heads the committee.

On June 6, at the opening of the Federal Radar Laboratory at Prince Albert, Saskatchewan, the Canadian Prime Minister, Mr Diefenbaker, announced that a Canadian satellite would be launched in 1961 with the co-operation of the American space agency. Canadian experiments are also to be flown in U.S. rockets. The Canadians are anxious to make fuller use of the facilities at the Fort Churchill rocket range which was established in time for the IGY as a joint U.S.-Canadian venture. So far almost all the rockets that have been fired from there have been American with American experiments on board. The Canadians are now developing high-altitude rockets as well as instrument packages of their own.

A week after the Canadian announcement came the Australian decision to form a national space committee. It was adopted at a meeting of the Australian Academy of Science in Canberra on June 8.

Because of their extremely isolated geographical position Australian Government scientists have been showing the greatest interest in weather satellite plans and also in the use of satellites as radio relays. It is thought that in the long run satellites will prove cheaper and more effective than providing an adequate network of weather ships and the additional projected deep-sea telephone cable across the Pacific.

The newly formed committee is to "coordinate the national space programme with similar activities overseas" and is the direct outcome of Australian participation in the COSPAR meeting at The Hague in March. The impression made on the head of the Australian meteorological office who attended the WMO meeting in Geneva in April, of the world weather satellite system proposed by the Americans on that occasion, has also been a factor in Australian space thinking.

Prof. L. G. H. Huxley, head of the Department of Physics of the University of Adelaide, a leading figure in the Australian Academy and a member of the famous Huxley family, has been appointed convener of the space committee. His view is that Australia has a strong obligation to exploit her unique geographical position in relation to space research. She is the only technologically developed country of large area in the southern hemisphere and as such has a key part to play in both optical and radio tracking of space vehicles—indeed, has been doing so with distinction from the first.

In Woomera she already possesses one of the best equipped and most conveniently placed rocket ranges in the world, and plans are already in hand to expand this substantially.

High-altitude research from Australia provides the only data so far being systematically obtained on conditions at altitude above the Earth's southern hemisphere. To extend this work the Australians have recently developed two solid-fuel sounding-rockets of their own, *Long Tom* and *Aeolus*, which have had successful trials and are now embarked on a research programme.

They have also made arrangements with the Americans to go into the field of rocket astronomy, the newest and one of the most ingenious means of studying the universe. The first spectacular rocket astronomy results were announced by scientists of the U.S. Naval Research Laboratory at last autumn's Moscow IGY meeting (see DISCOVERY, 1958, vol. 19, p. 475).

It will be interesting to learn what the space research budgets of these two countries is to be.

British Space Team Reports

At the end of June an eight-man team representing various British scientific interests, led by Prof. H. S. W. Massey, F.R.S., of University College, left for Washington to discuss with the National Aeronautics and Space Administration the terms on which the Americans would provide British scientists with the means of getting their experiments into orbit in an American earth satellite.

Prof. Massey and Mr R. N. Quirk of the Lord President of the Council's Office spent ten days in the States and returned a few days ahead of the others. The Lord President of the Council, Viscount Hailsham, has overall responsibility for the British space programme and a report on the negotiations was to be made to him by the middle of July. At the time of going to press no announcement had been made on the outcome of the talks. Prof. Massey said on his return that they had gone off "very much as he expected".

Rocket Launchings in the Sahara

In February it is understood fifty sounding-rockets were fired by the French from the Colomb-Béchar missile research base in the Saraha. Some were the 3000-lb., 23-ft.-long *Veronique* rockets (comparable in performance with the British *Skylark*), some the smaller *Monicas*, and some two-stage vehicles (formed from a *Monica* mounted above a *Veronique*) were also fired. The height range thus lay in between 30 miles and 130 miles.

High Elevation Beneath Arctic Ocean

On February 15 the Russian North-Pole-6 drifting station recorded a depth of only 2400 feet beneath the floe on which the station is located, at 86° 54′ N, 61° 40′ E, a position about 217 miles from the geographical pole and 347 miles north of Franz Josef Land. This is one of the highest elevations ever recorded beneath the Arctic Ocean. When the same drifting station recently passed over the Lomonosov submarine ridge which nearly divides the Polar Basin in half the shallowest depth recorded was still 3420 feet. Since the station started its drift in April 1957, recorded depths have usually been between 10,000 and 15,000 feet. The day before the recent record minimum was registered scientists on the floe observed a sharp decrease in ocean depth, from 14,100 to 9200 feet.

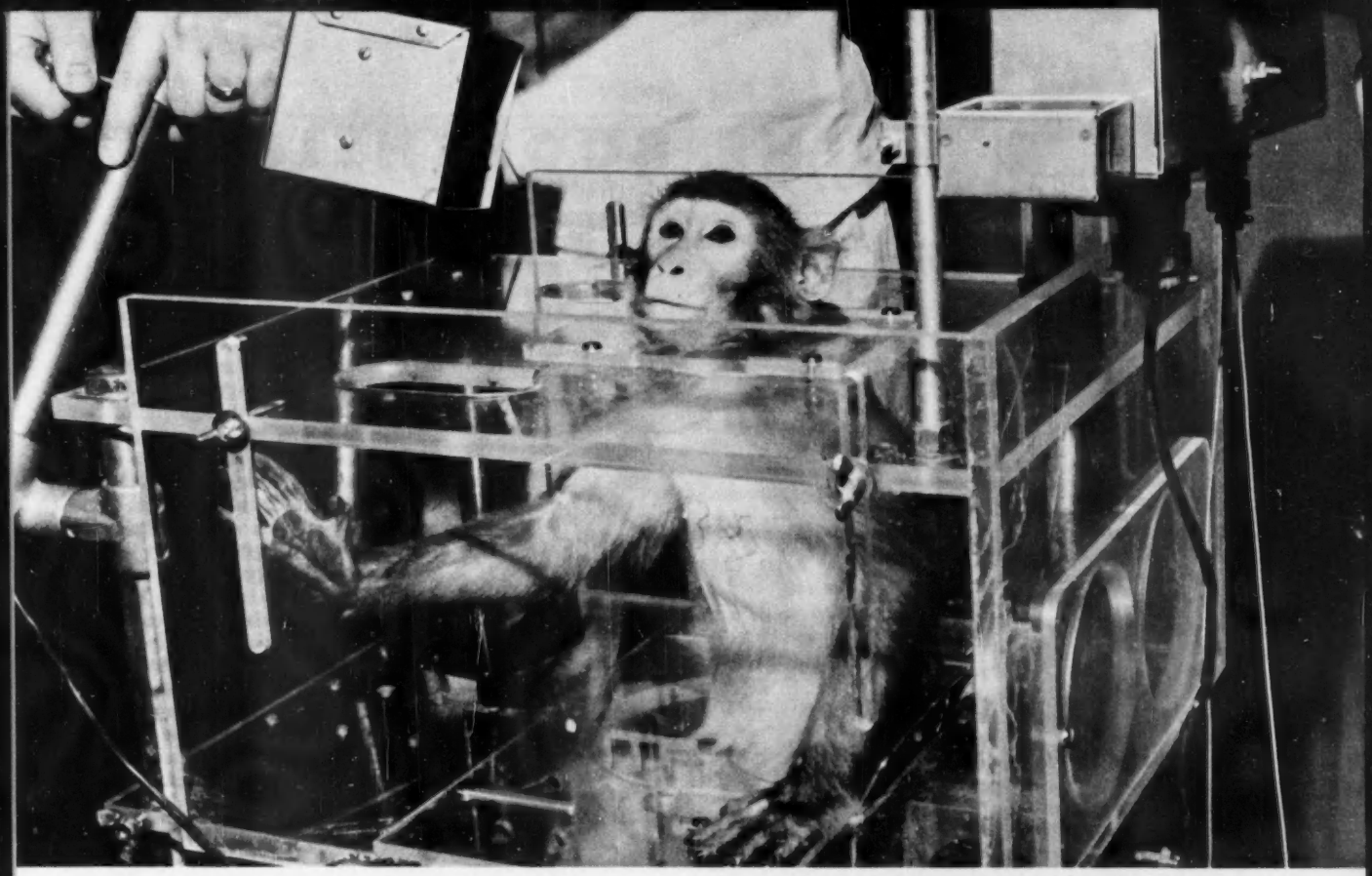
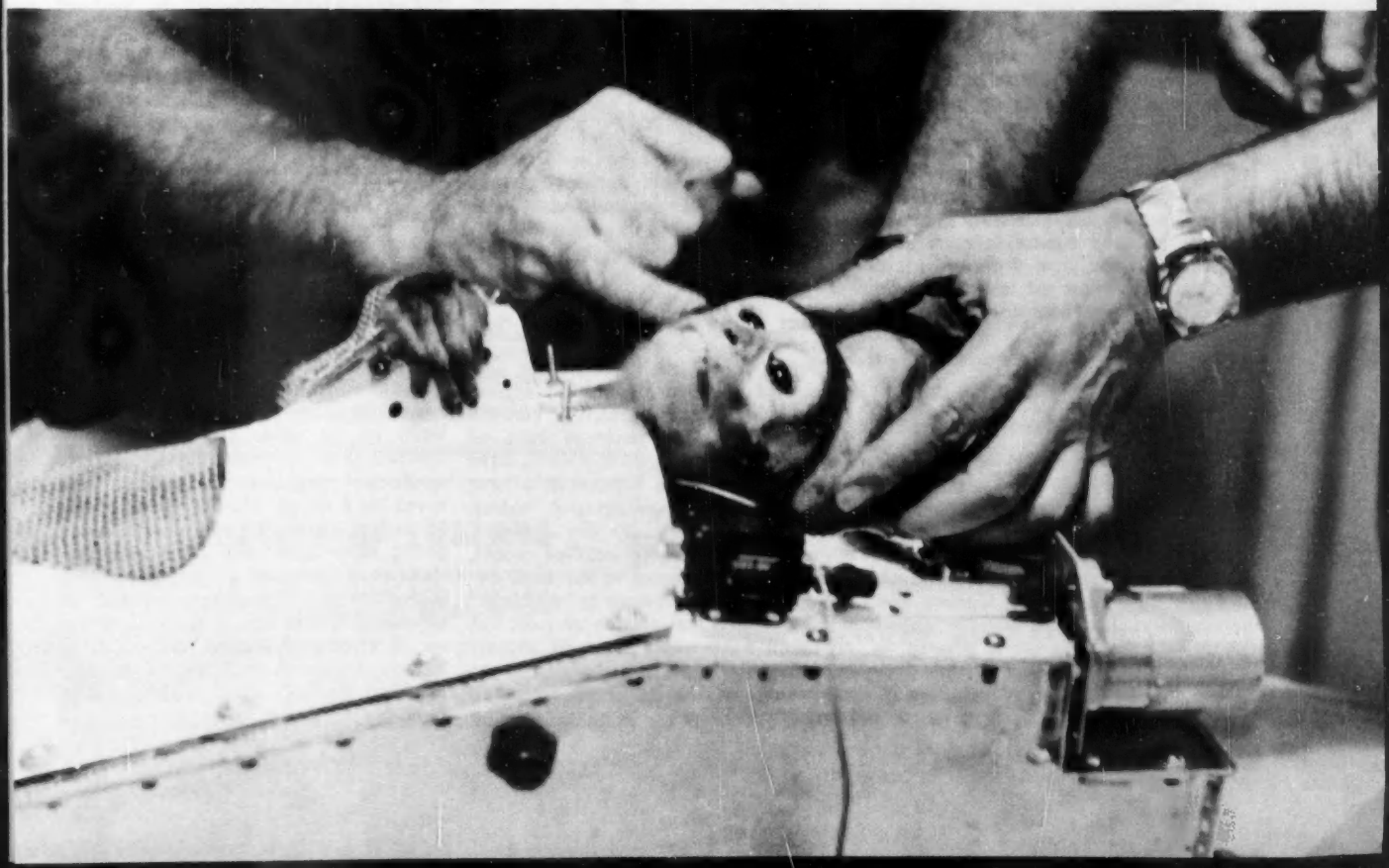
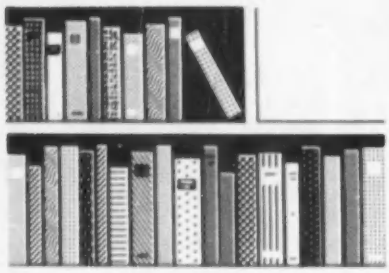


FIG. 1 (*above*). An American rhesus monkey receiving training before the *Jupiter* experiment. When the monkey, Able, touched the hand-switch a small red light flashed which was picked up by monitoring stations.

FIG. 2 (*below*). The monkey, Able, being released from the capsule which was inserted in the nose cone of a United States Army *Jupiter* missile launched from Cape Canaveral, Florida.





THE BOOKSHELF

Admiralty Brief

By E. Terrell, O.B.E. (*G. G. Harrap & Co., 1958, 240 pp., 15 plates, 21s. net*)

This book is the account of the inventions that contributed to the victory in the Atlantic over German submarines and raiders. The author, Capt. E. Terrell, R.N.V.R., was a barrister until he was drawn into the inner circle of "wheezers and dodgers", as Goodeve's team of workers was called.* His change of occupation was of the greatest value to the Merchant Navy, because his first and outstanding invention was plastic armour—the aggregate of asphalt and granite chips which withstood armour-piercing bullets. This was the armour that "you could stick a drawing-pin in" and which was turned down flat by the Directorate of Naval Construction on the grounds that it was not new and of no use. The author later received an award of £10,000 from a grateful Admiralty, but it is not recorded whether the DNC apologised.

The book is vividly written from beginning to end, and not the least interesting chapter relates to the capture of the U570 by an aircraft of Coastal Command—a boat which eventually became H.M.S. *Graph*. In reading through it one is conscious of the fact that the author must have enjoyed his brushes with established authority and routine, at least in retrospect, though the opposition must have galled him at the time. What a curious situation that most of the successful inventions of the war were developed against opposition instead of being encouraged! You will enjoy reading this book.

G. PARR

Fallacies in Mathematics

By E. A. Maxwell, (*Cambridge University Press, 1959, 95 pp., 13s. 6d.*)

This very readable book contains some thirty fallacies, nearly all of which are analysed in detail. The fallacies are classified according to their appropriate branch of mathematics—geometry, algebra, and trigonometry, differential calculus, and so on—and the final chapter is devoted to miscellaneous mathematical howlers.

Dr Maxwell says in his preface that his aim is to instruct through entertainment. It is probable that this book will entertain rather more than it will instruct; most of us are prone to commit those errors which provide the more subtle examples in this book, but very few of us can be "instructed" to avoid them.

Fallacies in Mathematics is worth buying if only for the amusement afforded by the last seven pages; perhaps some of the other fallacies could usefully be added to our school curricula?

J. C. PARR

Preparation of Single Crystals

By W. D. Lawson and S. Nielson (*Academic Press Inc., vii+255 pp., 46s. 6d.*)

This book proves to be a useful collection of otherwise isolated subjects, generally required to be known or understood in crystal growing: it contains chapters which provide an admirable summary of available techniques for growing single crystals of the more important semiconductor materials used to date, for preparing the materials prior to growing and for assessing the final product; the chapters discussing crystal imperfections are probably more advanced, however, than might be expected in work of this general nature, and might be considered as providing a minor out-of-balance.

The descriptive matter goes into valuable practical detail in many instances and the book as a whole could be recommended to form the training ground for graduates and other technical assistants coming into the field of semiconductor crystal preparation.

Where at the present time major interest undoubtedly centres in germanium and silicon, these two elements could have justified more detailed treatment than Mr Lawson and Dr Nielson have chosen. Again, the relatively lengthy treatment of vacuum techniques and distillation together with sublimation could, with advantage, have been shortened.

Certain terms are used without adequate explanation or description; a good example is "etch pit density". The description of the techniques of infra-red and microwave spectroscopy could have been strengthened in Chapter 6, as was done indeed for polarography, colorimetric analysis etc., by the inclusion of references to more detailed works. Curious errors appear in the text, for example "include" in place of "conclude" on page 4, and the mention on page 148 of Chapter 11 where no such chapter exists. In such respects the book gives the impression of having been prepared hurriedly.

H. W. L. CUMMING

Chemistry of Nuclear Power

By J. K. Dawson and G. Long (*London, George Newnes Ltd, 1959, 208 pp., 30s.*)

This book is written by two members of the Reactor Chemistry Group of AERE, Harwell. It gives a rather brief (203 pages) summary of the vast amount of information concerning the chemical aspects involved in nuclear power. In addition to a first chapter surveying the role of the chemist, the structure of the U.K. Atomic Energy Establishment, various chemical techniques, and so forth., there are chapters on raw materials (uranium, thorium, graphite, heavy water), fission and fission products, new heavy elements, separation processes, handling of radioactive materials, water-cooled nuclear reactors, gas-cooled and other reactor systems, disposal of radioactive wastes, and possible applications of radiation.

Whilst much useful information is gathered together in one place the treatments given are necessarily rather brief and, indeed, almost semi-popular in form; references only to further readings are given at the ends of chapters. Although the sections on uranium and thorium minerals, extractive technology, and the chemistry of the heavy elements and their separation processes cannot in any way be compared with the authoritative and exhaustive treatment given by Seaborg and Katz in "The Chemistry of the Actinide Elements", nevertheless this book does provide a useful purpose and should be suitable for undergraduate students, particularly for physicists or engineers who are interested in the nuclear energy field and who ought to have some appreciation of the very important chemistry involved therein.

G. WILKINSON

Stuttering

By Dominick A. Barbara (*London, Hutchinson Medical Publications, 1958, 255 pp., 25s.*)

The subtitle to this book is "A Psychodynamic Approach", by which the author means that stuttering should be treated in terms of the whole personality of the stutterer, and not merely as an isolated mechanical problem. Dr Barbara has based his book on insights gained about himself as a stutterer, and on his therapeutic experiences with other sufferers. The book contains a description and assessment of contemporary methods of treatment; it ends with a synthesis of the useful aspects of known therapy. It is intended for use by psychologists, doctors, teachers, parents, social workers, and stutterers themselves.

* See "The Secret War", G. Pawle (G. G. Harrap).

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Oliver and Boyd

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The Deep Range.

By Arthur Clarke (*London, Frederick Muller, 1957, 224 pp., 13s. 6d.*)

It is well known that the last few decades of scientific progress have changed the human world. Equally, it is well known that few have come to terms with this fact. Hence, so much science fiction is trash—our educational methods have left most people untouched by the true spirit of science, or the "discipline" of technology. A psychological gap exists between emotional realities for the individual, and the physical realities of the world he lives in. The author (and script writer) of science fiction can do much to bridge this gap. And people like Arthur C. Clarke are among the few capable bridge builders.

His story is based upon knowledge of a kind not available to earlier generations, namely the global population trend. Unlike our ancestors, we can predict that present rates of expansion will about double this planet's human population within a century. We know that food supply is a question of first importance. By the early decades of the twenty-first century, then, *Deep Range* pictures highly developed plankton farming, and also the systematic exploitation of the whale. Its migration is now regulated by submarine ultrasonic fences, and the whale's own food supply—that same green plankton—is thus treated as a controlled pasture.

The writer uses his first-hand knowledge of underwater work, and the Australian Barrier Reef, to give a story in three parts. "The Apprentice" is the unassuming title for a dramatic account of the training of ex-space-pilot Walter Franklin. He gets to know his whales, and feels as much for them and their ways as does an experienced cowboy on the cattle lands of America or Australia today. An accident to one of the "fences" allows an unusual predator (*Charcarodon*, the Great White Shark) to threaten the Right Whales herded for human nourishment. The "whale boys" go out, in their TV- and sonar-equipped submarines, to deal with the menace, and we are thus introduced to an, as yet, non-existent expertise. Franklin later undergoes a psychological upheaval, soundly enough interwoven with his personality; from a seemingly hopeless situation he is rescued—by a group of undersea big-game poachers.

"The Warden" tells of the hunting and successful capture of an animal known today largely by indirect evidence, *Bathyteuthis maximus*, the Giant Squid. Excitement is caught most plausibly as the great mollusc is finally immured, under an electrified net, in a floating dock. Happily they use also a sun-shield awning. (The absence of this in our own day, from the cage of the first captured *Coelacanth*, brought the unfortunate creature to an early end.)

National governments have at last been superseded—at least they are not mentioned—and the affairs of this planet are managed by the World Secretariat, answering to the annual World Assembly. At least one of the agencies of today's United Nations survives; a memorandum from the Division of Applied Psychiatry of the World Health Organization forms the substance of a chapter—set forth "in language understandable even to administrative officers." (*Sic!*) The FAO seems to have become the "World Food Organization", and the bureaucratic setting of our story is its Marine Division's Bureau of Whales.

"The Bureaucrat" involves us in a submarine earthquake, which brings tragedy and a vain ending to a search for a giant Sea Serpent, whose existence had been confirmed by undersea film cameras running for weeks at slow tempo. Then there is a development quite unexpected in this story set so firmly in the future. The whole basis of operation of the Bureau of Whales is challenged by an older organization—one older than Christendom. Here there are moral problems, and there are political pressures. Franklin's own conscience is on one side, his professional loyalties on the other. He is engagingly grouchy with his family. Without spoiling the story for those who read it, one can only say that both plot and character development are alive with freshness and humour.

Arthur Clarke is optimistic about the rate of colonisation of our near planets and—progress indeed!—he tells of *silent* space rockets, even at take-off. But the story is mainly terrestrial, and his forecasts, both technical and social, seem reasonable—all save one, and even that defaults as it were by absence. Europeans make up but a small proportion of the human race, they no longer breed prolifically and do not monopolise science and technology. Yet little, apart from Franklin's wife saying she is Dutch-Burmese-Scottish, reminds us that global technology is even now a multi-racial affair, and likely to be more so. That all the main characters are implicitly European, is the only criticism to be made.

Here is a story looking into the future with intelligence, humour, and optimism, and in tune with those forces of life which give us the world for a playground—if we want it that way. G. BELL

Guide to the Literature of Mathematics and Physics Including Related Works on Engineering Science

By Nathan Grier III (*Dover Publications Inc., 1958, xviii+436 pp., $2.49*)

This is a second, revised edition of a work first published twelve years ago. It is a critical bibliography containing more than 5000 entries under approximately 120 subject-headings. Whilst there is a distinct bias towards applied mathematics the list is so extensive that no mathematical library which caters for research workers can afford to be without it.

The author communicates his enthusiasm for books to the reader in four introductory chapters. The details of library practice apply mainly to the U.S.A. and are of little value to English readers; but the opening chapter on the principles of reading and study could be read with profit by many university students whose teachers often give them little guidance, assuming (quite wrongly) that a student enters university already knowing how to use books properly. Another chapter on the strategy of literature search will be of equal value to the newly qualified graduate seeking to find his feet in a field of research.

The book provides a great opportunity to pick up new ideas, and also to meet old friends. But browsers are to be warned. They will find it a permanent temptation. T. J. FLETCHER

Chinese Scientific Literature

The Lending Library Unit of DSIR has started to collect Chinese scientific literature. About 150 Chinese periodicals are now on regular order and the first batch has arrived at the Library's London premises.

This was announced in the March issue of the recently introduced *L.L.U. Translations Bulletin.** In a special article, the Bulletin suggests that we cannot ignore the scientific output of China, which may be growing rapidly.

Already the Lending Library Unit is noted for its large collection of Russian scientific literature, which is available to research, industrial, and other organisations, through a loans service. The library also organises a scheme for the translation of Russian scientific literature, in collaboration with the National Science Foundation in the United States. This may possibly be extended in the future to include scientific literature from China. Meanwhile, the contents of these Chinese publications must be assessed, and a scientist with a knowledge of Chinese has joined LLU to select and promote use of Chinese scientific and technological literature.

The Lending Library Unit in London is the nucleus of the new National Lending Library for Science and Technology, which will be set up at Thorp Arch, near Boston Spa, Yorkshire, in 1961.

* *The L.L.U. Translations Bulletin*, published for DSIR by H.M.S.O., price 4*s.* 0*d.* (4*s.* 5*d.* by post).

The Chemistry and Biology of Yeasts

Edited by A. H. Cook (*New York, Academic Press Inc., 763 pp., $22.00*)

There are several recent textbooks and monographs dealing with particular aspects of yeast growth, such as classification, technology, and pathogenicity, but until now none which has attempted to deal with all facets of the biology and biochemistry of yeasts. The book under review does this and thereby fills what has hitherto been a large gap in the available textbooks on microbiology. The book follows the modern fashion in comprehensive works of this type and consists of thirteen chapters, each written by people who are actively engaged in research and are authorities in their own particular fields. This can sometimes result in accounts being somewhat biased, but in this book the individual authors have succeeded in presenting impartially all points of view on controversial topics, particularly in the fields of classification, cytology, and genetics. Each chapter is more up to date than might reasonably have been expected in these days of high-pressure research.

Chapter I, dealing with Classification, includes much new material not present in any other book on Yeast Taxonomy and is the most up-to-date account of this subject available at the present time. It includes a discussion of the problems involved in the classification of yeasts, the techniques currently used, and concludes with a description of the main properties of all the ascosporogenous and asporogenous yeast species. Chapter II (Ecology) collates a lot of information which previously was widely scattered throughout the scientific periodicals and should be very useful to anyone interested in isolating fresh strains of particular yeast species. The account of the Life History of Yeasts (Chapter III) is a generalised one based largely on *Saccharomyces cerevisiae*, although it is shown how a few other yeast genera fit into the general pattern and it includes discussions of haplophase and diplophase states, of the importance of mating type in conjugation and of recent work on the occurrence of polyploidy in yeasts. The description of yeast Cytology is exclusively concerned with *Saccharomyces*. It would have been useful to have included some indication of the present state of knowledge of the life history and cytology of other yeast genera. Some good photomicrographs illustrating yeast cytology would have been preferable to the simplified, and probably incorrect, diagram which is included. Yeast genetics, the subject of Chapter IV, has been developed almost entirely during the past fifteen years and has caused considerable controversy because of the many apparent exceptions to simple Mendelian segregation. The various factors which might play a part, such as polymeric genes, complementary gene action, overlapping generations, supernumerary mitoses, mutation, and cytoplasmic inheritance are all discussed.

A long chapter on the chemical composition of yeasts deals with every conceivable substance present in yeast cells, from the components of the ash to individual enzymes, mitochondria, and subcellular particles. It even enters into the realm of the mechanism of action of some of the enzymes and a discussion of permeability and of the location of enzymes in particular cell structures. Some of this material would have been included more logically in other chapters.

The various factors influencing the growth of yeasts are dealt with at length in Chapter VI, including sources of carbon and nitrogen, growth factor and mineral requirements, temperature, and aeration. Useful accounts of the methods available for inducing sporulation and of preserving yeast cultures are also included.

The biochemical activities of yeasts are described in Chapters VII, VIII and IX, and the outstanding fact here is that they deal almost exclusively with only two species, *S. cerevisiae* and *Torula utilis*. This is not due to any failure on the part of the authors to include work with other species; such work is almost non-existent. There is some unbalance in the account of Fermentation and Respiration, where the reactions of the Embden-Meyerhof-Parnas system and of the hexose monophosphate pathway are dealt with in great detail, whereas the citric-acid cycle is dismissed in three pages. This is the only chapter which is not quite so up to date or complete as it might have been. Chapter VIII deals principally with the nature, degradation, and synthesis of poly- and oligo-saccharides. Chapter IX is a full and excellent account of Nitrogen Metabolism, not only of yeasts but of bacteria and moulds as well. It covers the breakdown and synthesis of amino acids, proteins, purines, pyrimidines, and nucleic acids, discusses current theories of protein synthesis and adaptive enzyme formation, and concludes with a short section on sulphur metabolism in yeasts. The two chapters on carbohydrate metabolism would have been improved if they had been given the broad treatment accorded to nitrogen metabolism.

There follows a chapter on technological aspects of yeast production for baking, brewing, food, and medicinal purposes, and chapters on pathogenic yeasts, the role of yeasts in food spoilage, and, lastly, on flocculation, a phenomenon, of considerable importance in the brewing industry.

As the Editor states, there is a certain amount of duplication between different chapters, but this is not serious. So far as your reviewer is aware, there are no major omissions in any of the subjects covered in this book, but sometimes the information one seeks is not in the obvious chapter. However, the book is well indexed both for subject and author. Your reviewer would have liked to have seen a section in which cytological observations, chemical analysis of cellular and subcellular structures, and enzyme localisation were brought together and discussed as a whole. Biochemistry is now reaching the stage where structure and function should be treated together and not separated into water-tight compartments.

There are a number of minor typographical errors in the text and an error in the formula for folic acid on p. 166, but otherwise the book is up to the usual high standard associated with publications from Academic Press. In summary, this is a good book and a valuable addition to the literature on microbiology.

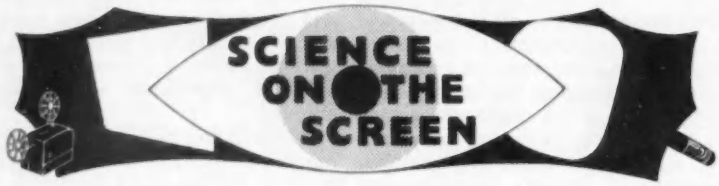
R. DAVIES

The Journal of the British Interplanetary Society has appeared in a new form with a bright blue cover. Since 1946 this publication has contributed a great deal to the scientific background of space exploration and has earned through its academic and serious contributions a very high respect throughout the world. It is obviously necessary for a journal of this type to expand and if the level of contributions remains at the same height, its more attractive presentation should make it even more valuable than it has been so far.

Solving the Scientist Shortage

By David C. Greenwood (*Washington, D.C., Public Affairs Press, 1958, 65 pp., $2.00*)

This is a brief survey of the current situation in the United States. The author gives eleven reasons for the shortage in scientific manpower and describes the programmes for professional training already being offered by governmental, industrial, and professional agencies. The book ends with recommendations for future programmes derived from the questionnaire returns of the 1957 Engineering Development Survey of the Los Angeles Chamber of Commerce.



Science Broadcasting in Canada

Serious science broadcasting began only recently and very modestly in Canada. In the past year, however, development has been rapid and the response from viewers and listeners encouraging and surprising. A letter from one viewer is indicative:

> "I watched your programme concerning Darwin's Theory. And would like to get further information concerning this. I am a theology student at Toronto Bible College. This programme was quite interesting since this aspect has never been presented to me before. Previous to this I used to consider it a sort of fairy tale."

Two hundred other viewers chose to comment on the same broadcasts.

It is an axiom of Canadian life that popular new ideas in the United States begin to operate in Canada after a time-lag. After the successful launching of *Sputnik I* the American Press, radio, and television began to issue science features. Public interest in science was aroused first in America, then Canada. In many respects Canada is still catching up with the interest in science on the part of the American networks and Press.

More than a year ago the Canadian Broadcasting Corporation began to reorganise and expand its scientific output —first in radio then on television. It appointed a programme organiser in the Talks and Public Affairs Department to co-ordinate these efforts on a national network scale. The result has been programmes of general information in many fields as well as instructive programmes on physics and chemistry. However, as a measure of the Canadian time-lag, it is interesting to note that only one Canadian daily newspaper out of more than one hundred retains a qualified, full-time science correspondent. This fails to measure up to the American lead which has produced many competent science correspondents to interpret new developments to the public.

In planning science broadcasts in Canada, the CBC had the benefit of British, French, and American experience. The programme organiser appointed by the CBC began his task by an analysis of tapes, kinescope recordings and scripts obtained from other broadcasting organisations. Though not a scientist himself, he had previously spent a year with the applied physics group of Harvard University preparing a series on the philosophy of science for the Educational Television Network in the United States. Before this, he had spent six years in Public Affairs broadcasting in Canada. He was, therefore, familiar with the methods of broadcasting and Canadian audiences, and had sufficient scientific knowledge when looking for programme topics and broadcasters. His analysis of broadcasts from the United States and Europe suggested that science broadcasting there followed a rather haphazard pattern. American television networks tended to place their science programmes in what they called the Public Affairs Ghetto between 4 p.m. and 6 p.m. on Sundays. They seemed to rely on costly, impressive, but short series, rather than sustained efforts. In the United Kingdom, Tuesday evening seemed to be a place for irregularly scheduled BBC television features. RTF in France offered similarly casual schedules of science programmes. In radio, on the other hand, American and European networks adhered to more regular programme periods suitable to the audiences they thought were interested. As for content, basic science seemed to receive less attention than research or technology. Apart from the Educational Television programmes in the United States, there seemed little attempt to organise formal science instruction. It is important to remember that this survey was made more than a year ago. Programmes and schedules have changed since.

The survey was followed some months later by a series of intensive discussions between the programme organiser and scientists in the United Kingdom and France. Similar discussions with Americans are planned. The European discussions did not change the basic findings of the survey. Indeed, it became even more apparent that there was little attempt to balance the broadcasts, in both radio and television.

In the United Kingdom and France, it seemed that various aspects of technology formed the basis for most programmes, that science was considered too difficult for a general audience and no thought had been given to formal instruction, if one excepts Sir Christopher Hinton's series "The ABC of Atomic Energy".

CBC science programme plans were based on the information obtained in the United Kingdom and France. A number of programmes treating general questions of science in a general way were broadcast. Among these were two television series, "The Sense of Science" which emphasised the unity and interconnexion of the sciences, and "Tomorrow is Now", a series illustrating the demands made on technology by its own successes. Though the demands made on the audiences for these programmes were considerable, the critical and public response was almost unanimously favourable.

Two twelve-instalment series on physics and chemistry were produced by the CBC in co-operation with the University of Toronto and McMaster University in Hamilton and broadcast in the Toronto area. Despite their more technical content a very large mail response caused the CBC to issue recordings in other areas. An impression of the sort of letter received is given by one writer:

> "It is instantly thought-provoking, immediately educational, and thoroughly entertaining to a degree that is to leave one bordering on impatience. Impatience that is not satisfied until the following programme in the series is seen."

Many students wrote to the broadcasters with specific questions.

Other television programmes now in production include a short medical series, dealing with such diverse questions as senescence, maternal deprivation, and the spread of an epidemic. A thirteen-programme series of biographies of scientists is being filmed in Montreal with leading Canadian actors.

A successful radio series, "Science Review", will shortly begin its third summer with interviews and talks ranging from the measurement of small time-intervals to blueberry culture in the Atlantic provinces. During the past year, Sir Robert Watson-Watt has acted as chairman for a number of discussions between scientists concerned with learning machines, operations research, and vigilance problems. It is hoped to extend these serious radio programmes in the coming year, possibly by means of a frequency modulation network.

In addition to these formal series, special science programmes have been produced as the news of the day merited, though a lack of this sort of on-the-spot science information has constituted a weak link in the overall pattern of science broadcasting.

However, in attempting to balance general information and instruction, technology and science, entertaining and serious programmes, a start has been made. It is fortunate that it has been a

good start. With the time-lag between American and Canadian enthusiasms, it is foreseeable that, should the American public turn its back on the science information coming from newspapers, television, and radio, the reaction could influence Canadians. The continued expansion of science broadcasting in Canada thus depends, to a certain extent, on how well busy American science "communicators" do their job.

D. WALKER

Ethnographic Films

Ethnographic film-making is as old as the cinema itself, but it is still difficult to describe exactly the films which fit into this category; however, they are generally considered to be those films which show the daily lives of people in all parts of the world—the so-called civilised inhabitants as well as the more usual films of the lives and customs of, for example, primitive tribes in some remote part of Africa.

In 1958 the Ethnographic Film Committee of Great Britain and Northern Ireland was started under the chairmanship of Mr Hugh Pitt. The Committee, which is a permanent body administered by the Royal Anthropological Institute, hopes to stimulate and extend interest in ethnographic films. To this end the Committee recently gave its first public presentation at the National Film Theatre. Two of the films shown were examples of the amateur and professional approach to ethnographic film-making.

First, the amateur production, entitled *Sherpas of Nepal*, was made by Prof. C. von Fürer-Haimendorf, an anthropologist at the University of London (and a member of the Ethnographic Film Committee), when he spent nine months in a Sherpa village on the approach route to Mount Everest. This film showed life in a Sherpa village. The first part explained how the Sherpas have very little agriculture, other than for their own needs, and that their trade (of incense and yak hair) with the Tibetans is their main contact with the outside world. In the spring the whole village migrates higher up the mountains, where it stays for the summer to graze the few cattle and grow potatoes and buckwheat—the main diet. Two interesting sequences were, first, a Buddhist festival where the monks, dressed in brilliant clothes and horrific masks to frighten evil spirits, performed religious dances; second, Prof. C. von Fürer-Haimendorf was able to go to a Buddhist monastery and film the life in it—the prayer-wheels being turned, and the young abbot, said to be the reincarnation of his predecessor. Though this was only an amateur production, there were some excellent shots of the barren and rugged country.

The second film, a professional one, was made by Mr Charles Lagos, with a commentary by Mr David Attenborough. Entitled *Highland Tribes of New Guinea*, this black-and-white film, which was originally recorded for television, showed specific incidents in the lives of the tribes inhabiting the Wahgi Valley, an interesting contrast to the amateur anthropological film which gave only a general overall picture of the life of the Sherpas. The Wahgi Valley tribes are of an ancient civilisation and wear birds-of-paradise headdresses and carry stone axes. (The valley was first discovered in 1937 by two gold prospectors.) The first half of the film is devoted to two incidents in the lives of one tribe: first, a ceremonial dance whereby the young people of the village get to know each other; second, a wedding, a very solemn affair, where the main concern of all the participants seems to be their wish to get their fair share of the dowry.

David Attenborough, who takes part in the film, then goes to find the people who make the stone axes. On this journey over uncontrolled territory there is an alarming encounter with a warrior tribe and also a sequence showing how salt, a very precious commodity, is obtained. Finally, there is a fascinating sequence on the making of the stone axes. Nowadays they are large and unwieldy and only used for ceremonial purposes.

The Ethnological Film Committee hopes to follow its first film presentation with many more. It wants to encourage the use of ethnological films in schools and universities, and in the future the Committee hopes to be the distribution centre for the films.

Earth and Sky

By Stephen Toulmin and June Goodfield. 16 mm., colour, music, and commentary, 45 minutes. (*Distributed by the Education Foundation of Visual Aids. £3.*)

At some time or other scientists and those interested in science have to sit back and take stock. The applications of science in our lives today would seem to be but a foretaste of what will be the impact of discovery and applications of discovery in the years ahead. Yet the actual everyday results of science are not the only effects which scientific development brings. We are, gradually and more subtly, influenced by the changing outlook which new discoveries and new hypotheses bring in their train. There is a need, then, to stand still, to review, and to look back, sometimes over a long period. We must do this, not least, in order to get things into perspective.

The history of science is, therefore, an important study and may, of course, be a means of bridging the gap between the science specialists and the arts men for it is, in many senses, a common study. But we must take care. The historian may be, and often is, interested in the biographical details of important characters, and such interest is necessary in assessing an individual's significance and making some attempt at discovering why this or that particular result has occurred. Yet the greatest need at the present time is for broad and general sketches to be made. It is indeed vital that something be done towards sketching pictures of the history and development of scientific thought. Therefore the urgent requirement is for as broad an approach as possible rather than for detailed cameos of the historically famous.

Prof. Stephen Toulmin and Miss June Goodfield have clearly recognised this, and have had the courage of their convictions. They have boldly attempted to present in forty-five minutes a colour film sketch of man's changing views about the movements and nature of the sun, moon, and planets. The result, *Earth and Sky*, is to be commended; it is full of imagination, interest, and in many sections, visual beauty. Prof. Toulmin has himself commented that the film succeeds in fits and starts but there is much in it that is more than well worth seeing.

The film begins with the work of astronomers of ancient Babylonia. As is well known, their records were inscribed in cuneiform script on clay tablets which were then baked. The film actually shows such tablets being prepared with astronomical data and, rightly, the commentary tells us that the science of astronomy was born in Babylonia. In all, the Babylonian section is very good. The outlook of Greek astronomers is next considered and views are given of the Greek countryside; these stress well the clear atmosphere, the commentary explains how more rational theories of the universe were drawn from daily experience, and hints are given (with views of a moving cart) of Greek physics. There is also a very good sequence showing the motion of the Sun and the subsequent motion of the Sun's shadow cast by a style. It is well known that the later Greeks propounded the view of epicycles, and this is well shown in the film by the use of an ingenious device which traces out the apparent paths of a planet which moves round the earth in an epicycle. The machine used was specially made for the film but one feels that perhaps the commentary could have stood a reference to the fact that the whole basis of the device is, in fact, a system of epicyclic gears. The contribution of Islam is briefly sketched with some delightful pictures showing Arabic texts. The effects of using

circular motions with the sun as centre are shown in what is a new technique and is, from a film point of view, perhaps the most memorable section in *Earth and Sky*. A very ingenious device is used in which a ball represents the planet Mars; this rotates on an arm about a pivot which represents the sun. The movie-camera is fixed to another arm again pivoting round the sun but with a linkage so arranged that the camera lens is always pointing in the opposite direction to the sun-pivot. In brief, we have a model in which the observer (in the form of a movie-camera) can watch the normal and retrograde motions of another planet. The film goes on to discuss briefly the work of Copernicus, Tycho Brahe, Kepler, Galileo, and finally something is said of the work of Isaac Newton.

As a whole, the film lacks the polish of the professional. This is not so much a criticism as a comment. The script is good, but would have been improved if it had contained less—there is too much to take in, especially in the second section where the ideas of Kepler, Galileo, and Newton are traced. Moreover the breadth of coverage means that the producers have had to pass over so many twists and turns of Egyptian, Babylonian, and, more to the point, Greek ideas that one is liable here and there to get the wrong impression and so even be misled. Nevertheless, the film is a brave attempt to make a broad approach to a difficult subject. It is certainly worth seeing and should give scientists, scientific-film producers, and sponsors much food for thought. The Nuffield Foundation are also to be praised for giving financial assistance for so novel a venture. Let us hope that now Prof. Toulmin and Miss Goodfield have shown the possibilities of the medium their pioneering work will be followed up. It certainly deserves to be.

C. A. RONAN

The Viking Rocket

Edited by M. F. Allward. 30 frames black and white with teachers' notes. (*Produced by the British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1.*)

This filmstrip sets out to outline some of the problems involved in testing and launching a large liquid fuel rocket. The Viking was developed by the Martin Company, Baltimore, Maryland, U.S.A., under the technical direction of the U.S. Naval Research Laboratory. It was originally designed in 1946, but it is an advanced vehicle capable of lifting a useful payload to altitudes exceeding 150 miles. The introduction to the filmstrip in the notes gives a rapid, but clear description of the rocket. Unfortunately much of this information is not illustrated in the filmstrip. A few frames devoted to background information, with diagrams, would have strengthened the whole presentation. Your reviewer longed for one or two explanatory diagrams to hammer home what was happening and why.

The strip is divided into four parts. It uses existing photographs to show in the first part some of the processes of manufacture. The second part shows handling and transporting the rocket. The third part shows testing, and the fourth, launching. The frames are interesting but they do not go in close enough to show the details mentioned in the notes. Nevertheless I can imagine it being of value to schools.

This strip does its job quite efficiently, but it does it in a way which is visually distracting and technically difficult. Instead of the standard English practice of using a vertical strip with single frames of 35 mm. film dimensions, the pictures are horizontal. They are what is called double frame, that is, the proportion of the pictures are 3 : 4 instead of the more usual 2 : 3. This means that the user has to remove a mask in the filmstrip carrier, or show only the central part of the picture. He also has to turn the carrier round and get used to turning the knob in a different position, and for a different distance. Certain projectors are not made to show horizontal filmstrips.

This raises one of the inevitable problems of international co-operation. For whereas the English and American filmstrip users are standardised on the vertical filmstrip, the Dutch and Scandinavian use the horizontal. They do this because it fits in with the Leica format.

There is another disadvantage to the horizontal strip which has been proved by research. Habitually we move our eyes on a horizontal plane. Many people pass through a street for years without ever consciously looking at the tops of buildings. When the projected image is changed by bringing it in from above, the movement is small, and our eyes wait, glued to the centre of the screen, for the next picture. When the picture comes in from the side, the movement is longer; however, we follow the old picture off the screen and then go back to the new one. This is more tiring to the eye and inclined to distract the mind.

In principle one should never use existing photographs just as they are for a filmstrip. This is particularly obvious in "The Viking Rocket". The images vary in shape and size, some filling the whole frame and some only a relatively small sector in the centre. This fault can be avoided easily enough by choosing the part of the picture required, blowing it up to a standard size and retouching the print. With careful retouching, all irrelevant parts of the picture can be removed and important parts emphasised. It is this careful selection which makes the difference between mere projection and a brilliant visual aid. Naturally the standard size retouched photographs are rephotographed for the strip.

I feel especially disappointed that an organisation like the British Interplanetary Society, should have adopted a type of rather primitive presentation which comes out like a magic-lantern lecture. The techniques of filmstrip production can, and should, be forward-looking. We should learn from what others have done.

After careful consideration there is no doubt that this will be a useful strip. But as the subjects which are likely to be dealt with by the BIS are so important scientifically, I should like to see them adopt a more rounded and complete treatment. They have done what their sub-title says they will do: "Outline some of the problems involved in testing and launching a large bi-propellant rocket." What they have not done satisfactorily is to explain why there are problems.

I plead strongly for serious scientists, publicists, and teachers to study visual material more carefully before they try to produce films, filmstrips, or charts. Even the best book and journal illustrations do not automatically make projection grade. Every visual-aid designer must think not only of photographic quality, and standards of art work, but of communication. Does the image convey an exact message which is completed by the teacher's words? If not, it is not a good aid. The job of turning pictures into communication tools is exciting but hard.

L. GOULD-MARKS

Films at the York Meeting of the British Association for the Advancement of Science

The 1959 Meeting of the British Association for the Advancement of Science will be held in York from September 2 to 9. The Meeting will include a series of scientific film programmes compiled from recent film productions selected from all over the world, which either present scientific subjects to informed non-specialist audiences or demonstrate the use of film in scientific research.

Erratum

We regret that on page 231 of the June issue of DISCOVERY we referred to Prof. R. C. Jones of Queen Mary College. This should have read Prof. G. O. Jones.

FAR AND NEAR

Wellcome Expansions

At the beginning of May four new buildings were officially opened at the Wellcome Research Laboratories. These buildings are part of the laboratories' five-year development plan.

Work at the laboratories is organised in two main divisions: the Therapeutic Research Division and the Biological Division. The work of the former is directed towards the discovery and manufacture of new drugs and that of the latter covers the fields of bacteriology, biochemistry, immunology, and virology, and is also responsible for the development and large-scale preparation of a comprehensive series of biological products for both human and veterinary use.

Premises for the preparation of biological products demand the highest standards of cleanliness. This is especially applicable to virus vaccines prepared from tissue culture, where it is necessary to provide sterile working conditions no less exacting than those in a modern surgical operating theatre. Moreover, since research and development on virological products is a continuing activity, it necessitates a constant revision of methods and technique. New premises should, therefore, not only meet the strictest existing standards but be built for easy conversion to new techniques or functions with the least disturbance to the work in hand, the greatest possible speed, and the lowest possible cost. This has been done at the Wellcome Laboratories by housing the servicing installations in voids between the corridors. This form of construction allows maintenance engineering and servicing alterations (such as temperature control in a specific laboratory) to be carried out without breaking sterility during processing.

The poliomyelitis vaccine building was the first new one to be completed and is planned for the production of approximately 4 million doses of vaccine per annum. (See DISCOVERY, 1958, vol. 19, p. 142.) There are three other new buildings which are now complete. The first is for the production of virus vaccines, which will eventually include yellow-fever vaccine, influenza vaccine, canine-distemper vaccine, and canine-hepatitis vaccine. The production of yellow-fever vaccine and canine-distemper vaccine has already started. The second of the two virus buildings has been provided for research and development work on viruses of importance in medical and veterinary practice. At present it also accommodates the poliomyelitis vaccine safety testing laboratory.

The third of these three buildings is devoted to work on anaerobic bacteriology: research, development, and vaccine production for animals, mainly sheep. These diseases include lamb dysentery, pulpy kidney disease, black disease, blackleg, blackquarter, braxy, and enterotoxaemia.

The rest of the development plans are still in early stages. But finally there will be a building devoted to research, development, and production of antisera for both human and veterinary use, and for various prophylactics, mainly for human use. There will also be a new Pharmacology Laboratory, and various schemes are planned for renovating old buildings for research and production.

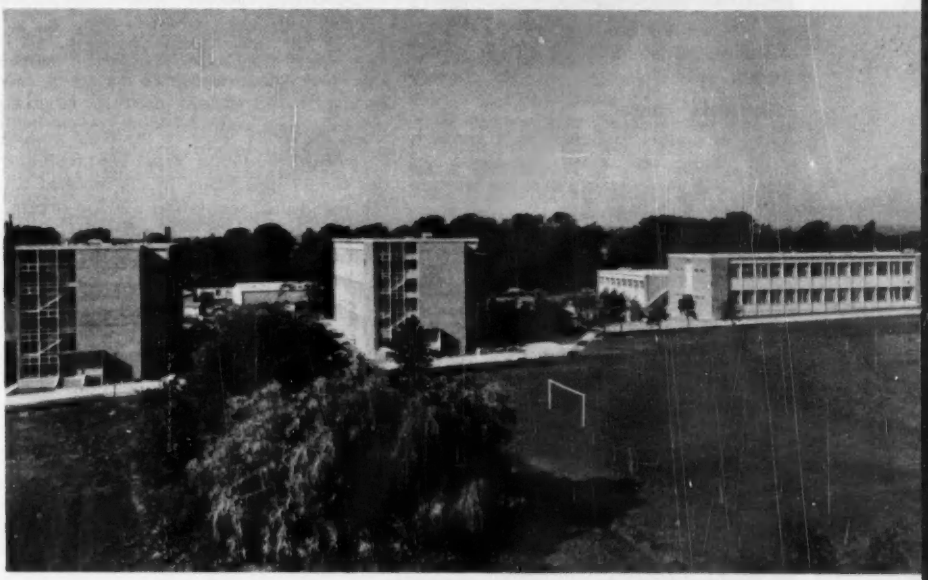


FIG. 1 (*above*). Part of the new Wellcome Research Laboratory Buildings at Beckenham.

FIG. 2 (*below*). Colour test for potency of poliomyelitis vaccine at the Wellcome Research Laboratories.

FIG. 1 (*above*). A view of the tiny settlement established at the foot of Mont Blanc. Two hundred technicians who are working on the Italian section of the tunnel live here. There are shops, offices, workshops, and the central compressor station for the drills and ventilation in the mountain on the site.

Mont Blanc Tunnel

A motor tunnel is being built through Mont Blanc and when completed, in 1961, it will considerably ease the journey from Paris to Milan.

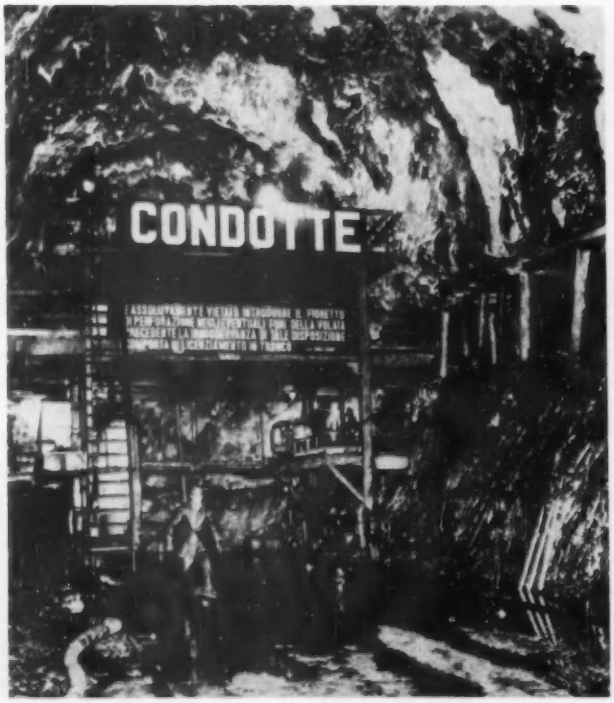
Work started in the autumn of 1958 and progress is governed by the speed of the drills: 14–20 in. a minute. Therefore, each drilling of 13 ft. takes about eight hours, and is followed by the charge and explosion. Thus speed has averaged 26 ft. daily. This however will be slowed down when the drills come to the hard granite core of the mountain. Pipes are taken into the tunnel and bring in compressed air for the drills, ventilation air for breathing, and take away the water that seeps through the rocks.

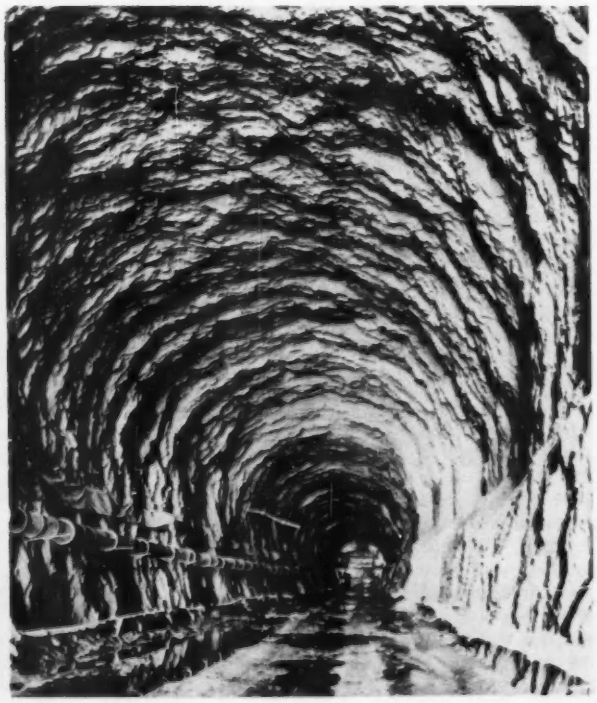
The drills (sixteen at a time) operate on a specially made platform on rails which enables the miners to reach the tunnel face. When the charges are inserted, it is drawn back for the explosion. Then the dumpers drive in to clear the rock and deposit it in the valley below the entrance.

The actual length of the tunnel will be seven miles. It will cost £12 million and more than 13 million tons of rock will have been removed to make the tunnel which will have a face area of 861 sq. ft. The height will be 31 ft., the width 27 ft., and the roadway will be 11 ft. above the base of the tunnel to allow for the installation of services.

FIG. 2 (*below*). The specially designed drilling platform on rails which enables the miners to reach the 861 sq. ft. tunnel face. The Italian miners attack the rock with sixteen lightweight Atlas Copco Tiger rock drills. During each shift some 140 holes are drilled 13 ft. deep into the rock and charged with dynamite. On the platform is the miners' safety rule No. 1: "Never insert a drill into a hole already drilled. It may contain the remains of a charge"

FIG. 3 (*below*). A view of the tunnel.





Kalinga Prize to Prof. von Frisch

Prof. Karl von Frisch, zoologist and scientific writer, who is well known for his research on the sensorial physiology of insects, bees, and fish, was awarded the Kalinga Prize for the popularisation of science.

The prize of £1000 is offered annually by the Kalinga Foundation which was set up to contribute to economic, social, and cultural progress in the Indian State of Orissa. Its winner is chosen by an international jury appointed by UNESCO.

Prof. von Frisch is the author of more than a hundred scientific studies, the most remarkable of which deals with his research on bees, their life, language, and sense of orientation. These studies have helped scientists to probe such mysteries as how insects and birds are able to navigate so accurately. Prof. von Frisch's experiments have shown that bees' eyes see polarised light in the sky, enabling them to distinguish zones of different shades by which they can orient themselves.

George de Hevesy Receives Atoms for Peace Award

Prof. George Charles de Hevesy, of Sweden, has been awarded the second Atoms for Peace Award. The Hungarian-born chemist and teacher was selected unanimously and he will receive a gold medallion and $75,000 for "his basic contribution to the peaceful uses of atomic energy in the discovery and development of tracer techniques in chemistry, biology, and medicine using natural and artificial radioactive and stable isotopes".

In tribute to Prof. de Hevesy, it was said:

> "He was the first to apply both natural and artificial isotopes to the study of plants and animals; he introduced the use of stable isotopes and he was the first to explore the possibility of creating radioactive substances within the system being studied by means of neutron bombardment.
>
> "These discoveries, now adopted in laboratories and hospitals all over the world, are certainly among the most important advances in the peaceful use of atomic energy in our time."

Born in Budapest in 1885, de Hevesy took his doctorate at Freiburg in 1908. After a period of study in Switzerland and Germany, he went in 1911 to work with Ernest Rutherford in England. Here he failed to separate Radium D from lead. This failure resulted in de Hevesy's development of the use of the radioactive element (now known to be an isotope of lead and not readily separable from it by chemical means) as a tracer for lead, first reported in 1912.

From 1913 to 1920 he was at the University of Budapest; in 1920 he joined the Institute for Theoretical Physics in Copenhagen, and in 1943 was awarded the Nobel Prize in Chemistry.

Since the Second World War he has worked in Copenhagen and at the Research Institute for Organic Chemistry in Stockholm, his present home.

Science in Parliament: June 2–19

Parliament's reassembly after the Whitsun recess (June 2) began with questions on scientific and industrial research. News was given of the preliminary visits exchanged between the British Iron and Steel Research Association and a corresponding research organisation in the U.S.S.R., about scientific cinematography, progress by the Water Pollution Research Laboratory in investigating "anaerobic digestion" of slaughterhouse wastes, research on the susceptibility of prestressed concrete to damage by fire, progress in the design of hydraulic machinery for use in hydro-electric pump storage schemes, and on the tests by the Warren Spring Laboratory of a catalytic device to reduce pollution from petrol-engine fumes. Written questions elicited that the total cost of agricultural research borne by the Ministry of Agriculture was £1¼ million (June 3), and that the cost of the recovery of methane gas from sewage was generally proving uneconomic (June 8).

The Prime Minister was again questioned on radioactivity (June 2). He outlined the main international agencies for keeping the problem of radiation under close and continuous review, but Opposition spokesmen said that in view of the confusion arising from different scientific advice from several governments, an early report from a UN scientific body was desirable. The existence of a threshold for radiation was again probed: the Prime Minister stated that it was impossible to say whether or not such a threshold existed. He also reminded the House (June 4) that diagnostic man-made radiation was at least 22% of background radiation compared with 1 or 2% from fall-out, and he was waiting for the report of Lord Adrian's committee on man-made radiation with a possible view (June 2) to more careful control.

On June 4 there was an Adjournment Debate on research into and treatment of migraine. Whereas official statistics showed migraine consultations at 1·2%, it was suggested that in fact about 5 million people are affected. Attention was drawn to the success of treatment at the Putney Migraine Clinic—outside the National Health Service. A Government spokesman explained that migraine constituted a set of symptoms occurring from quite different causes: research in many directions was being undertaken, a number of drugs had been tested, and he claimed that adequate facilities were available inside the Health Service.

Finally (June 3), in the Lords, the Government were asked to appoint a Royal Commission to inquire into causes of the increase in crime, since no one could pin-point the real cause of the very serious increase (almost exactly matched in two countries, Sweden and Switzerland, with living standards as high as Great Britain's), and partial inquiries through existing agencies were unsuitable. The Lord Chancellor, replying, and supported by other speakers, said that the problem of causation raised complex social questions, that the tools for such study (sociology, psychology and criminology) were comparatively new, and that research on a number of fronts through a number of disciplines undertaken by the universities and encouraged by the Government was more suitable than the hearing of evidence by a Royal Commission. In sad contrast to this welcome scientific approach to crime was a debate on road accidents (June 10) where the scientific aspects of accident research and causation were barely touched.

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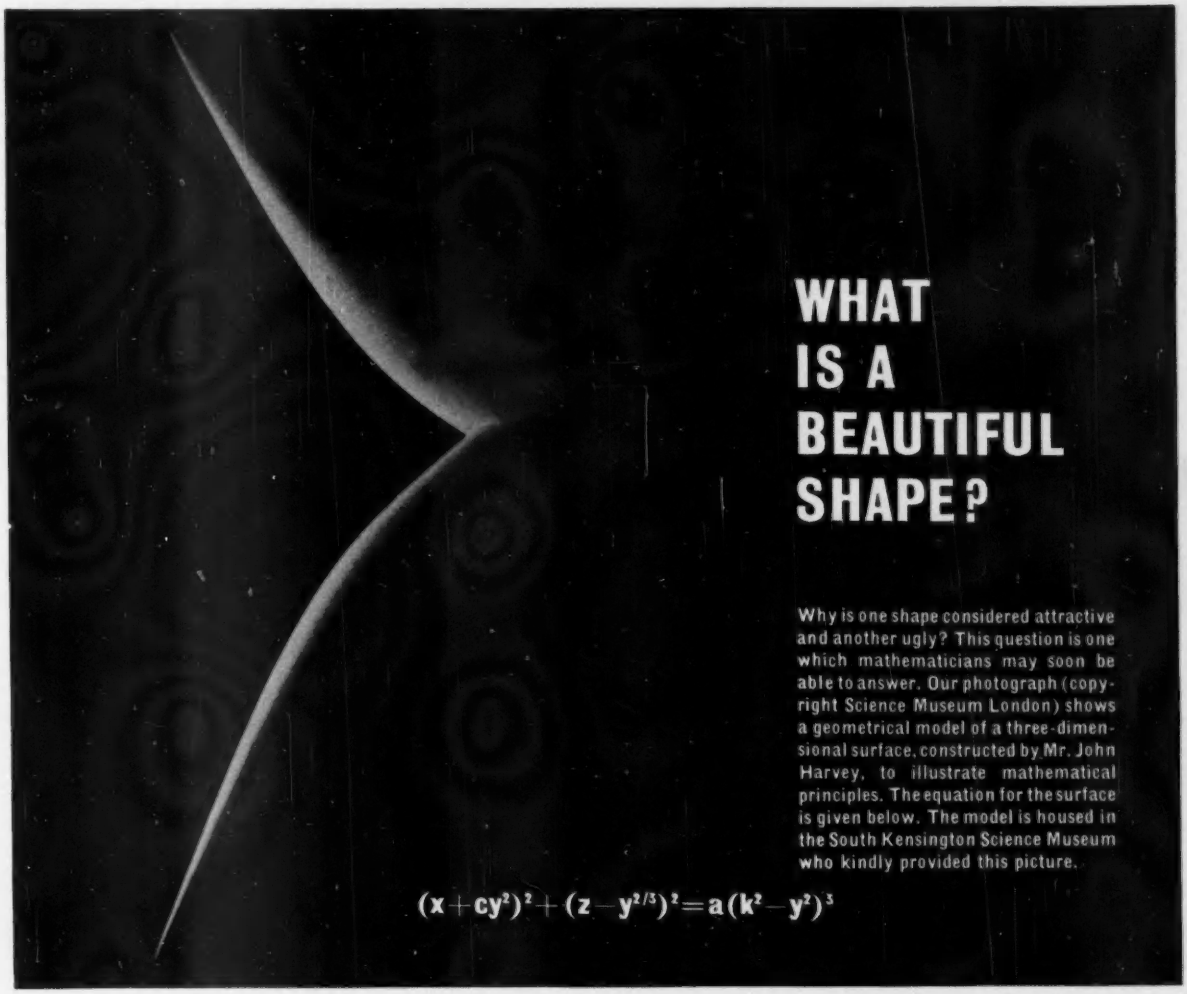

WHAT IS A BEAUTIFUL SHAPE?

Why is one shape considered attractive and another ugly? This question is one which mathematicians may soon be able to answer. Our photograph (copyright Science Museum London) shows a geometrical model of a three-dimensional surface, constructed by Mr. John Harvey, to illustrate mathematical principles. The equation for the surface is given below. The model is housed in the South Kensington Science Museum who kindly provided this picture.

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